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A Member shall be an officer or employee of a public or private water works, an engineer, chemist or other person qualified to aid or interested in the advancement of knowledge relative to water works.

An Honorary Member shall be a person of acknowledged eminence in some branch of water supply or of engineering.

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An Associate shall be either a person, firm or corporation engaged in manufacturing or furnishing materials or supplies for the construction or maintenance of water works.

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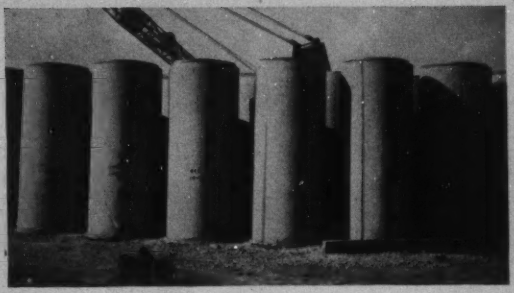
This Association has seven regular meetings each year, of which five are held at Boston, one in a New England state other than Massachusetts, and one, the annual convention, in a city determined by the Executive Committee.



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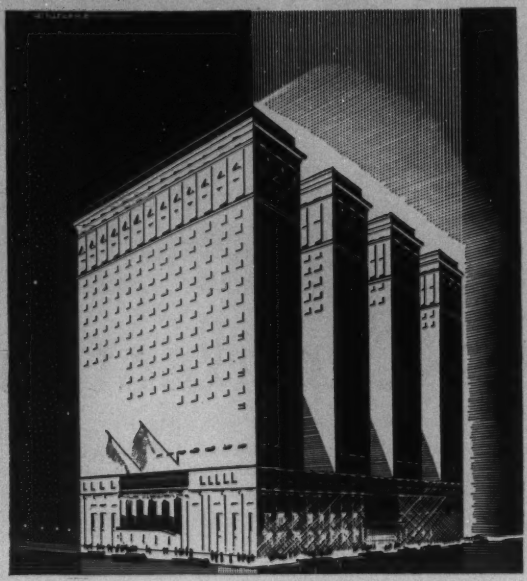

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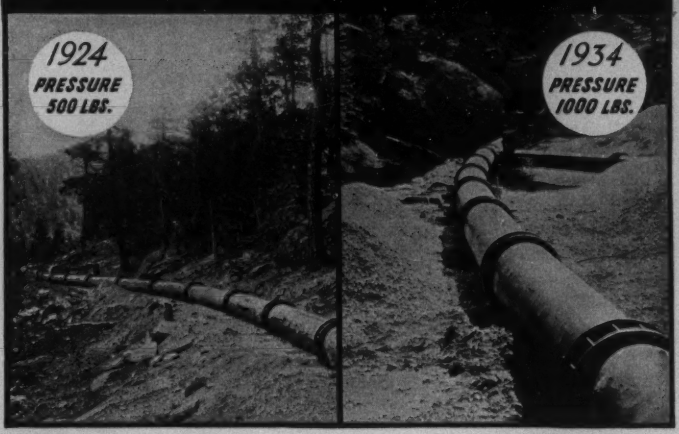

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New England Water Works Association

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This Association, as a body, is not responsible for the statements or opinions of any of its members

SOME RECENT DEVELOPMENTS IN BRITISH WATERWORKS PRACTICE.*

BY HAROLD J. F. GOURLEY.†

[*Read September 24, 1936.*]

Introduction. The Institution of Water Engineers was honoured by the presentation of valuable papers by Mr. Saville and Mr. Chase at its meeting in Harrogate in June, 1931, and further by your subsequent cordial invitation that there should be a periodic exchange of papers between your Association and the Institution.

I was delighted to be nominated by the Institution to contribute the first of what, I hope, will be a long series of papers, and it is with particular pleasure that I am able to be present at this Convention, for I am convinced that, apart from what may be learnt by an interchange of information through postal channels, there is no doubt that personal contact makes not only for a better appreciation of the technical aspects of our common field of service to the community, but, even quite as important, must help in some measure to a better and closer understanding between the two English speaking nations.

On behalf of the Council and Members of the Institution of Water Engineers may I say that we shall always be delighted to welcome any of your Members, who may find themselves in England, to our meetings which almost invariably take place in Whit-week and again early in December, and, apart from such occasions, our Secretary will be pleased to put any visitors in touch with those engineers responsible for works in which these visitors may be particularly interested.

Many of the problems with which we have to deal are common to our two countries, and I propose to refer to some in the hopes that they may touch a responsive chord and that I shall carry back your views upon these subjects.

* *Editor's Note:* This is the first paper to be exchanged between the Institution of Water Engineers and the New England Water Works Association.

† Consulting Engineer, Westminster, London, England.

Underground Water.

I was interested to read in the April Proceedings of the American, Society of Civil Engineers a paper by Harold Conkling, M. Am. Soc. C. E., on the Physical and Legal Aspects of the Administrative Control of Underground Water, and this has led me to a brief statement of the position in England today.

In 1859 it was established by our highest legal tribunal—the House of Lords—that the rights of riparian owners, in respect of water flowing in visible surface streams or in known and defined channels, do not apply to underground water which simply percolates into and through the ground and has no certain course and no defined limits. From subsequent cases decided in 1881, 1886 and 1902 it was made clear that a "defined" channel is one which is definitely contracted and bounded, although the actual course of a channel may be undefined by human knowledge, and further that a defined subterranean channel must be "known", not through excavation but by reasonable inference from observations on the surface of the ground.

These decisions therefore placed upon an owner claiming riparian rights to the flow of water in a subterranean channel the onus of proving the existence of such a channel without recourse to excavation, and as recently as 1932 this statement of the legal position was affirmed.

The engineering aspect of the matter is therefore, shortly, that there is no property in underground water and as the general law stands in England today, there is nothing to prevent the sinking of a well on land immediately adjacent to the site of an existing well to the possible detriment of that well.

As between neighbouring industrial concerns using underground water the principal effect of the existing law has been that when Peter robbed Paul the only remedy was for Paul to rob Peter, and the only satisfied people were the well sinkers.

Within the last ten or twelve years, however, a new and more difficult position has arisen owing to the growth of industries in which one works alone might use up to several million gallons a day, and, in pumping such large quantities, so deplete the underground supply of the district in which the works happen to be, as adversely to affect the yield of public wells upon which the community relies for all or part of its domestic supply.

In order that the position may be the more fully appreciated, it is perhaps as well to describe briefly how a public authority or statutory water undertaker—as distinct from a private concern—obtains the powers to sink a new well; a private individual or manufacturing concern has only to buy land in order to have the undisputed right to obtain such water from underground as the strata are capable of yielding.

Parliamentary Plans are deposited in both Houses of Parliament and a Bill is prepared describing the "Works" for which powers are sought and including, amongst other clauses, a "protective clause." At the same time,

by notices published in the newspapers all persons or authorities likely to be concerned or affected are made aware of the proposals of the Bill, and, in due course, the Bill is the subject of enquiry in turn by a Committee of each House. The promoters and the various opposing interests are represented by Counsel and supported by Engineers and other technical witnesses, and in the sequel the Bill emerges as an Act upon receiving the Royal Assent, though generally with amendments put upon the promoters by one or other Committee, or inserted by agreement with opponents. It is by such an Act that a public authority is authorized to purchase land and sink a well or wells, and construct other works connected therewith. For less important works, and where there is no opposition a simpler and less expensive procedure is available when the Minister of Health has authority to grant a Provisional Order which has subsequently to be confirmed, if not then opposed, by Parliament.

For the past thirty years most, if not all, of the private Acts involving wells include the protective section mentioned above. By this the owner of any well or spring (and sometimes pond) within a specified radius, used for water supply, who can prove that his supply has been diminished as a consequence of the pumping at the authorised well, is entitled to compensation in water or otherwise. The radius of protection varies with the geological formation, or in special circumstances, but it is usually one mile for wells in the chalk and two miles for wells in the triassic sandstone formation.

Until this year there was no case of reciprocal protection being given to the public authority, and nothing in law to prevent a large industrial concern, with the knowledge that the authorised well had proved the presence of a large supply, from sinking its well immediately adjacent to the authorised well and developing it to such an extent as most seriously to reduce the yield of the authorised well.

The Wolverhampton Corporation was obliged to seek Parliamentary Powers for additional wells in part to meet the growing needs of its area of supply, but in part because one of its authorised wells had had its supply reduced from 1 500 000 to 700 000 g.p.d. in the course of eight years, and this was attributed to the pumping of increasingly large quantities (at present about 2 000 000 g.p.d.) from the same triassic formation by an industrial concern whose works were less than a mile away, and evidence was given to the effect that, in the course of a few years, the yield of the Corporation well would become so small as not to be worth pumping.

In this case the promoters inserted the usual protective clause in their Bill with a radius of 2 miles, but coupled with it a reciprocal clause by which no landowner within the same radius could, after the date of the Royal Assent, sink a well or otherwise abstract underground water, except with the consent of the Corporation, other than for the domestic supply of persons on his land, for the watering of stock or for other purposes of an agricultural nature connected with the product of his own land. It was not

the intention of the Corporation to impose undue restrictions on the normal development of the lands within the 2-mile radius, but the clause was definitely directed to preventing the incursion of the large industrial works.

It was provided that on refusal of consent by the Corporation the landowner may require the Corporation to afford a supply at cost price to the Corporation, but the Corporation are not bound to do so, if by so doing it interferes with the Corporation's ability to maintain either the supply for domestic purposes within its statutory limits of supply or with existing trade supplies, nor if the aggregate of such supplies, together with what water was necessary to compensate owners of existing sources within the radius of protection, exceeds the yield of the authorised well.

For many years past, waterworks undertakers have been pressing for general legislation to control the development of underground sources, and advocating a system of licensing in which regard would be had to the limits of the potential yield of particular underground basins, and during the past two or three years the Institution of Water Engineers, acting jointly with other associations representing public water interests, has made representations on these lines to the Ministry of Health, and a Joint Committee of both Houses is sitting to investigate this and other matters, and the Minister has supported the Joint Recommendations of a Triple Conference of representatives of the Institution of Water Engineers, the British Waterworks Association and the Water Companies Association, which were unanimously approved by each of the three bodies. To some extent the Wolverhampton decision is in advance of any change in the general law which may be recommended by the Joint Committee, and since, in the absence of general legislation, Parliamentary Committees are much influenced by precedents, the Wolverhampton Act will help meantime to correct the anomalous position in which water undertakers now find themselves.

Compensation Water.

It is realised that in America the compensation of riparian owners whose interests in a river may be affected by the construction of impounding reservoirs by means of "Compensation Water" is the exception rather than the rule.

The majority of the earlier impounding schemes carried out in England about the middle of the last century, were located on streams in Lancashire and Yorkshire and comparatively near to the towns they were designed to serve. These streams were in many cases already extensively used for industrial purposes by mills, bleach and dye works situated below the proposed point of abstraction. In those early days, reliable data as to the yield of catchment areas was practically non-existent. The only information then available was that afforded by rain gauges established on or in the neighbourhood of the gathering ground: such gauges were usually few in number, and the records were taken only over a short period of years, and, in some cases, at irregular intervals.

From such records as were available the average annual rainfall was estimated, one-fifth or one-sixth was deducted to arrive at the average rainfall of the three driest consecutive years, and a flat deduction was made of so many inches of rain — generally fourteen — to cover losses by evaporation and absorption, the remainder representing the average run-off or maintainable yield of the river during each of the three years, and quite usually one-third of this yield was fixed as the quantity to be discharged as compensation water to the river, leaving two-thirds as the yield for the town's supply. Assuming the correctness of the basis of calculation, and having regard alike to the use to which the river was put and its régime of flow in relation to the geological character of the catchment area, it is probable that one-third of the maintainable yield was not an excessive amount of compensation in the circumstances of those cases.

But the precedent created in those days was applied in subsequent cases where the conditions were widely different, and in many of these cases there is little doubt that the discharge of as much as one-third put an unreasonably heavy burden upon water undertakers, and ultimately, upon the consumers. All riparian owners within 20 miles below the point of abstraction are entitled to be heard when the Bill comes up for consideration by Parliamentary Committees.

These considerations led to an investigation by a special committee which reported in 1930 to the Minister of Health and the recommendations in that Report on Compensation Water, subject to some amendment in the light of further deliberation, have been advocated by the Ministry of Health in its evidence before the Joint Select Parliamentary Committee on Water Resources and Supplies.

The main grounds upon which a revised basis of assessment of compensation water is advocated are as follows:—

(1) That the faulty rainfall records on which compensation water has been fixed in past years have led to greater quantities of such water being discharged in a number of cases — in other words the reliable yield had been over-estimated — and revision is recommended.

(2) That the allowance or deduction for loss by evaporation is generally too low.

(3) The present method of assessment it too rigid; it does not allow sufficiently for the wide variation in the character of the streams, i.e. there is no differentiation between a "flashy" stream with small dry weather flows of little use to industrial users who seldom have more than a very limited storage, and high peak flows of short duration which cannot be utilised, and the stream which has a steadier régime which is of greater value to the industrial user.

(4) Apart from the character of the stream itself, there is not sufficient difference made in the amount of compensation water allowed to streams with a large measure of industrial user, and that allowed to streams but little used for industrial purposes.

Even now, it is sad to relate that the new basis advocated is not founded entirely on river gaugings, for, although rainfall records now cover satisfactorily substantially the whole of the country, we still, with few exceptions, have no long period records of natural river flow, and, therefore, still will have to estimate the loss in specific cases, though the principle that

this will vary not only with differences in rainfall but also with geological and other considerations is recognised. The loss in the three years may average from 12 to 16 in., and in exceptional cases it may even be outside that range.

To one interested in hydrology, the conception of a "characteristic" designed to meet the third point, as recommended by the Committee on Compensation Water, as a measure of the variations in flow to which any stream is liable, is justification for referring to it in some detail.

If a weir and recorder be installed at the inception of a scheme, a continuous record of flow over the period of 4 to 7 complete, though not necessarily calendar, years required for construction becomes available,

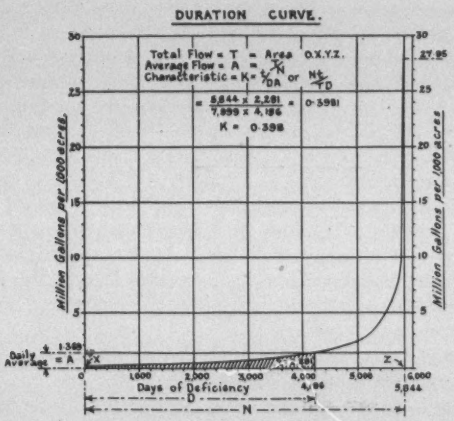


FIG. 1.— DURATION CURVE.

and this can be utilised to calculate (A) the mean daily flow over the period of gauging (which should not be less than 4 years), and (B) the average daily flow on those days when the river flow was equal to or less than the mean during the whole period of gauging: the ratio $\frac{B}{A}$ is the characteristic K.

In Figure 1,* which is a reproduction of a diagram in the Report on Compensation Water, the figures are in relation to each 1 000 acres of catchment; the total flow amounted to 7 999 m.g. during the 5 844 days of the continuous gauging record, and the corresponding average was 1.369 m.g.d. The number of days during which the flow was equal to or less than this average was 4 186 (or 72 per cent.), and the total flow during those days 2 281 m.g., so that the corresponding average was 0.544 m.g.d.; the characteristic in this case was $\frac{0.545}{1.369}$ or 0.398.

* Reproduced by permission of the Controller of H. B. M. Stationery Office.

The more this is considered, the better does it appear to give a reasonable measure of the variability of stream flow. The characteristic varies from 0.32 to 0.48 in the ten streams the records of which were investigated by the Committee. Of course, for the ideal river of constant daily flow the characteristic would be unity. It is also interesting to note that within quite close limits the flow on all these rivers over the period of the gaugings (4 to 19 years) was equal to or less than the average for 65 to 70 per cent. of the time.

To legislate for the nature of the use to which the stream is put the Committee introduce a "user factor", which ranges from 0.35, for a river which flows through a rural area having only a few small mills and possibly fishing interests as well, to 0.70 for a fully industrialised river; the larger figure may be said to give compensation more or less commensurate with the one-third if the "characterisitic" is 0.48.

The daily discharges of the unreservoired River Brenig in North Wales have been recorded since February, 1922, and to show how relatively little the characteristic varies on the basis of 4-year periods, Table 1 has been prepared.

TABLE 1.— ANALYSIS OF BRENIG FLOWS.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
4 years ending Sept. 30.	Total flow M.G.	Max. daily flow. M.G.	Min. daily flow. M.G.	Average daily flow over 4 years. M.G.	No. of days when flow was at or below average.	Total flow during those days. M.G.	Average daily flow during those days. M.G.	Characteristic. Col. 8 / Col. 5
1926	16 380	111.7	0.4	11.22	1 047	4 800	4.59	0.41
1927	17 550	183.4	0.4	12.02	1 041	5 420	5.20	0.43
1928	16 920	183.4	0.4	11.60	1 047	4 860	4.64	0.40
1929	16 230	183.4	0.4	11.13	1 033	4 320	4.18	0.38
1930	17 630	183.4	0.4	12.08	1 030	4 550	4.42	0.37
1931	18 210	225.2	0.4	12.48	1 011	4 570	4.52	0.36
1932	17 860	225.2	0.4	12.24	1 011	4 760	4.71	0.39
1933	17 980	225.2	0.7	12.31	1 006	4 920	4.89	0.40
1934	14 670	225.2	0.7	10.05	1 030	4 080	3.96	0.39
1935	13 020	103.9	0.7	8.94	1 033	3 584	3.57	0.40

The catchment is covered by boulder clay almost entirely, and its area is 4 997 acres. It will be noticed that the minimum flow is 0.4 m.g.d. (0.15 c.f.s. per 1 000 acres) which is distinctly low, though not so low as that recorded on an adjoining area in 1911, where from 6 313 acres the discharge fell to 0.19 m.g.d. (0.056 c.f.s. per 1 000 acres). As the Brenig flows through a rural area, with only a few mills and some fishing interests, the recommendations of the Committee would give a range of $0.36 \times 0.35 = 0.126$ to $0.43 \times 0.35 = 0.151$ of the estimated average run-off of the three driest consecutive years as compared with 0.333 which was fixed by Parliament in 1907.

The effect of using 6-year periods is, as would be expected, to reduce the range of variation in the characteristic.

If the same method of analysis be applied to the River Thames, the results for 6-year periods are as set out in Table 2.

TABLE 2.— ANALYSIS OF THAMES FLOWS.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
6 years ending March 31.	Total flow. 1 000 M.G.	Max. daily flow. M.G.	Min. daily flow. M.G.	Average daily flow over 6 years. M.G.	No. of days when flow was at or below average.	Total flow during those days. 1 000 M.G.	Average daily flow during those days. M.G.	Characteristic. Col. 8 / Col. 5
1927	3 448	9 919	167	1 575	1 420	1 072	755	0.48
1928	4 172	9 999	167	1 906	1 405	1 360	970	0.51
1929	4 129	9 999	167	1 887	1 425	1 459	1 023	0.54
1930	4 248	10 489	167	1 931	1 413	1 322	937	0.49
1931	3 844	10 489	167	1 756	1 423	1 348	950	0.54
1932	3 741	10 489	167	1 710	1 442	1 292	897	0.52
1933	3 877	10 489	167	1 770	1 438	1 344	936	0.53
1934	3 188	10 489	167	1 458	1 442	1 127	782	0.54
1935	3 020	10 489	141	1 380	1 423	966	678	0.49

The drainage area of the Thames is 3 812 square miles; geologically there is probably not more than 15 per cent. of impervious clay, the effect of which is that a large percentage of the rainfall percolates into the pervious formations below, and a proportion of this reappears in the form of springs; the geological conditions and the relatively large size of the catchment alike tend to uniformity of flow, and this is reflected in a characteristic which is about 35 per cent. higher on the average than that of the Brenig.

The lowest recorded daily flow is 141 m.g.d. (0.107 c.f.s. per 1 000 acres).

The new method of assessment recommended is, therefore, to take the 80 per cent. of the average rainfall: deduct the appropriate loss by evaporation and multiply the result by the "characteristic" and by the "user factor" to give the compensation in inches of run-off.

If this method gains general acceptance, it will mean, in most cases, a reduction in the quantity of compensation water, in some instances considerable, and a corresponding gain to the community. The proposals have also been endorsed by the Triple Conference already mentioned.

REGIONAL WATER SUPPLIES.

In a country such as England, with great density of population in the industrial areas, the problem of meeting increasing demands for water has become more difficult. There is little doubt that, in the past, there has been an excess of civic pride and too much of what we call parish pump politics, and too little collaboration between authorities in the common interest. We have instances of two adjoining towns each collecting water from a relatively distant source, the aqueducts from which have either run in parallel for many miles, or, in certain cases, actually crossed. Clearly,

economy in many such cases can be achieved by joint action, for instead of two reservoirs being constructed each being in its early days drawn upon for but a portion of its estimated yield, one could be constructed and utilised more fully, and the construction of the second put in hand when a better estimate of future needs can be made than was possible when the first reservoir was contemplated. The Triple Conference has considered this aspect of the conservation and better utilisation of the water resources of the country, and its recommendations have been endorsed and advocated by the Ministry of Health. The water supply of an area, not of a locality but rather a region, is advocated; the limits of such a region being fixed by topographical and geological considerations rather than by legislative and political divisions, and the administrative methods by which such ideals are to be achieved are set out.

For many years past recommendations from authoritative committees for a proper survey of the water resources of the country have been put forward: like many other proposals of real merit and advantage to all, these recommendations have been ignored, for they required Government action, and such action is only too often dictated by political considerations, and, unfortunately, in England at any rate, there are no votes in water. However, the drought, to which reference is made later, has emphasised alike the need for regional operation and for a water survey, and at long last the need for a comprehensive water survey was appreciated by the Government, and it decided in 1934 that this should be undertaken.

In January 1935 a Committee was empanelled "to advise on the Inland Water Survey for Great Britain, on the progress of the measures undertaken and on further measures required and, in particular, to make an annual report on the subject." The first annual report has just become available, from which it seems evident that, unless public funds are drawn upon more liberally, it must be very many years before results commensurate with the ever increasing importance of the matter are likely to be achieved. With the present financial resources, the progress made in the investigation is good, but bricks cannot be made without straw, and it is still not realised that numerous gauging stations must be established without delay if records of any value are to be available in, say, twenty to thirty years' time.

The Drought 1933–1935.

The drought of 1887–89 had until the past three or four years been considered as affording a measure of the conditions which water undertakings must be able to meet.

In a number of cases it seemed clear that the results of the 1933–35 drought were more severe than those of about 50 years ago, and the Institution of Water Engineers now has a Committee at work investigating the records with the view to determining what changes are necessary in our basis of estimation of yield of water resources, in order that a repetition of

the conditions of 1933–35 should not involve shortage of water and possible hardship resulting therefrom.

As Chairman of that Committee I had hoped that the general results of this investigation might have been placed before you, for there is a general similarity in the hydrological conditions of the New England States and Britain, but the Committee is not yet in a position to formulate its findings.

One factor, however, which must surely emerge from the investigations is that the run-off from catchment areas and the percolation which replenishes underground sources is not so much a function of the rainfall of a period of years as of the incidence of that rainfall. It was not only the general deficiency of rainfall in the years 1933–35 which led to difficulties, but much more the fact that there was a serious deficiency in the rainfall of the six winter months, when normally both reservoirs and underground storage are strongly replenished, and whatever the rainfall of the summer months, its corresponding run-off and percolation are of relatively minor importance.

A considerable quantity of water is derived by pumping from the Chalk formation in the south-east of England, and the records of a percolation gauge, consisting of a natural section of chalk with its soil and grass covering, gave the following average results over a period of nearly 40 years. Rainfall of six winter months 14.32 in.: percolation 9.56 in.: the corresponding figures for the summer months being 12.47 and 1.99 in. respectively.

In upland gathering grounds where normally the geological formation is impermeable, a winter run-off equal to 70 to 80 per cent. of the rainfall may, on the average, be expected, whilst for the summer period 20 to 40 per cent., dependent upon whether it is more or less evenly distributed or concentrated in relatively heavy showers, is all that can be looked for.

Floods.

The flood discharge for which provision has to be made in the spillways of reservoirs is one of the most important factors in design, and it is a factor which it is by no means easy to evaluate.

In the Manual of Water Works Practice issued by the American Water Works Association one finds a selection of formulas from which the flood discharge for a given drainage area may vary over a wide range of proportion 1:3 to 1:8, and only one of these — that of W. E. Fuller — recognises that the provision to be made for a margin of safety should logically vary according to the circumstances. That the factor of safety should vary with the importance of the structure and with the consequential material damage and with the risk to life is undoubted. According to this formula, the factor would have a value of, say, 5 when great damage will result from the failure of a major structure or life is likely to be endangered thereby. This means that the flood value is 5 times the average yearly flood, and working back it implies a flood which may occur once in a period of 100,000 years.

In 1930 the Reservoirs (Safety Provisions) Act was passed by the British Parliament, and it placed a statutory obligation upon owners of reservoirs to provide for an inspection by engineers experienced in reservoir design and construction, whose duties would include a consideration of the adequacy of the spillway.

A study of such failures of reservoirs as have taken place in the past in different parts of the world, more particularly of reservoirs formed by the construction of an earthen embankment, indicated that such failures were only too frequently due to insufficient provision for the discharge of flood waters, and because in Britian there are many similar reservoirs with widely varying spillway capacity, a Committee of the Institution of Civil Engineers was set up under the Chairmanship of W. J. E. Binnie to investigate and report upon the provision which should be made in spillways to guide engineers in giving effect to the requirements prescribed by the Act of 1930.

A good deal of time was devoted to seeing how far any of the formulas extant gave results in accord with the flood records available, but the Committee eventually came to the conclusion that it was preferable to rely on actual records rather than attempt to arrive at the maximum intensity of flood discharge on theoretical considerations. As most of the Reservoirs in the British Isles lie in hilly districts or "upland" areas, enveloping curves were drawn to include the records covering areas up to 450,000 acres (about 700 sq. miles) and the Committee was of opinion that these curves represented the maximum rates of inflow likely to occur in all but exceptional cases, i.e. the curves represent what the Committee describe as "normal maximum floods." From an examination of the dates at which the recorded floods occurred it would appear that such floods are those liable to occur once in fifty or sixty years.

To give some idea of the magnitude of these normal floods the figures below are read from the curve:—

Drainage Area 1 000 acres.	1	10	100	200	400	700	1 000
Peak rate of reservoir inflow in c.f.s. per 1 000 acres.....	1 240	515	200	155	110	95	75

An area of 450 000 acres is about the limit of "upland" catchment in Britain, but for comparison with New England flood records the two last columns have been added, since it would appear that there is a similarity in topographical and climatic conditions with those in Britain.

From the records of the devastating New England Floods of March, 1936, compiled by Harrison P. Eddy, Jr., and published in "Civil Engineering" of May last, the following figures are abstracted, and in the last column are given figures based upon the Committee's curve of "normal maximum floods":

TABLE 3.

Location.	Drainage Area. Square miles.	Flood Discharge. C.f.s. per square mile.	Committee Report. C.f.s. per square mile. Normal maximum peak rate.
CONNECTICUT RIVER			
Comerford, Vt.	1 650	33.3	46
MERRIMACK RIVER BASIN			
Souhegan, Merrimack, N. H.	171	99.4	121
Pemigewasset, Plymouth, N. H.	622	105.7	77
Merrimack, Franklin Junction, N. H.	1 510	49.7	49
ANDROSCOGGIN RIVER			
Inflow to Gulf Island Pond	1 810	132.0	43
Outflow from Gulf Island Pond	....	70.7	...
BLACKSTONE RIVER			
Woonsocket, R. I.	416	32.3	90
SWIFT RIVER, Mass.	184	45.0	118
WARE RIVER	97	61.0	150

Without knowing more of the circumstances, particularly as to the extent to which the recorded flood discharges are affected by pondage and other factors, it is not possible to discuss these figures, but as they stand they are of great interest as an indication of the measure of similarity in the conditions prevailing in the two countries.

The only case where the Committee's curve extended seems to fall seriously short is for the inflow to Gulf Island Pond, and the discharge in that case is really astonishing; it is, as the writer observes, a consequence of the breaking of an ice jam and therefore to be regarded as of a catastrophic nature. It is presumed that the Pond is relatively large compared with the drainage area and the heading up considerable, for the reduction in the peak rate of outflow is almost 50 per cent.

The Committee also investigated the probable effect of reservoir lag by means of simplified hydrographs of inflow, and came to the conclusion that it played an important part. In these hydrographs, the duration of the peaks was based upon the observed tendency for the peak rate to be sustained for a short time for small catchments and for longer periods as the area increases: to any point in the hydrographs the accumulated run-off did not exceed a reasonable percentage of the rainfall, which could fall in the time, whilst the total run-off was assumed to be 80 to 90 per cent. of 3 inches running off in the period covered by the hydrograph, which period increased from 6 hours for a catchment of 2 sq. miles up to 20 hours for 40 sq. miles. For example, if the area of normal top water of the reservoir

was 5 per cent. of the drainage area, and the height to which the water could be permitted to rise over the spillway was 2 ft., the normal maximum peak rate of inflow as given by the curves previously mentioned would be reduced to 70 per cent. of that value, *i. e.* the spillway could be reduced to discharge that percentage of the peak inflow if the head was 2 ft. With a 10 per cent. reservoir and the same allowable head the reduction would be to 40 per cent.

Greater allowable heads were found to increase the lag effect, *e.g.* 4-ft. head and a 5 per cent. reservoir meant a reduction to about 40 per cent., whilst a 10 per cent. reservoir would give a reduction to 25 per cent., but the Committee recommend that in no circumstances should the reduction be to more than 33⅓ per cent., nor should the weir (for areas up to 25 000 acres) be capable of passing less than 150 c.f.s. per 1 000 acres under normal maximum flood conditions with the maximum permissible head, and in design the alternative which gives the greater length of weir should be adopted.

The Committee realised that there should be a margin of safety to meet exceptional floods, and, from a consideration of the intensities of maximum rainfalls for different durations and catchment areas which have been recorded in the British Isles, came to the conclusion that the peak rate of acute catastrophic floods may be estimated as at least twice those of normal maximum floods, and drew attention to the fact that rainfall of a catastrophic character has never been recorded in the winter months when a reservoir would normally be full, but has occurred at very infrequent intervals in other months when the reservoir would be less likely to be full.

The height between the level of the water when discharging normal maximum floods and the top of the embankment is defined as the margin of freeboard, and if this margin be 2 ft. investigation showed that it would be sufficient to cater for catastrophic floods provided that not more than 3 ft. was the limit of head under normal maximum flood conditions.

One further point in the recommendations of the Committee is that, with substantial wave walls on earthen embankments and a "fetch" of one mile, the margin of freeboard should be 2 ft.: increase of fetch calls for a greater margin, and the absence of a wave wall would necessitate a minimum margin of 3 ft.

The recommendations of the Floods Committee, which by its membership was one of authority, form a code which has received general professionl acceptance as indicating the criterion to be applied in design and in the checking of existing spillways of "upland" reservoirs.

Special circumstances may warrant spillways of smaller capacity, but the inspecting or designing engineer would have fully to justify any radical departure from the recommendations.

It has already been stated that the curves put forward by the Committee represent floods of a peak intensity liable to occur once in about fifty years, i.e. according to the Fuller basis, the factor of safety would be be-

tween 2 and 3 in terms of the average annual flood, but this factor would be doubled by the recommendations of the Committee in regard to the margin of freeboard. The highest factor of safety recommended by Fuller is between 5 and 6, and this agrees substantially with the recommendations of the Committee, for many of the reservoirs in Britain are so situated that their failure would be attended with loss of life and considerable damage.

Circular Spillways.

The discussion of floods and spillway discharge leads to a consideration of a type of spillway which has of recent years come more frequently to be used, for, in many situations, considerable economy in construction results from its use, since the bellmouth can discharge into a shaft which, in turn, discharges into the culvert or tunnel which carried the river past the site during the construction of the embankment or dam, and the cost of an entirely separate weir and overflow channel is avoided.

Such details as are available of this type of spillway within the British Empire are included in Table 4:

Table 4.

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Reservoir and Location.	Date of Construction.	Diameter of Crest. Feet.	Diameter of Shaft. Feet.	Diameter of Tunnel. Feet.	Discharge.	
					c.f.s.	Head. Feet.
Blackton (Tees Valley) England.	....	93	20	..	..	..
Font (Tynemouth) England...	1907	34½	15	..	..	..
Ponsticill (Taf Fechan) Wales..	1925	66	16	13	3 340	3.1
Powdermill (Hastings) England.	1932	22	8	8	1 100	3.0
Trentabank (Macclesfield) England.....	1926	10	6	6	500	3.0
Silent Valley (Belfast) Ireland.*	1930	80	16	16	2 600	2.2
Pontian Ketchil (Singapore) Straits Settlements.....	1932	50	13	13	2 700	3.1
Burnhope (Durham) England..	1935	50	12	12	2 630	2.25
Shing Mun (Kowloon) Hong Kong.....	1936	74	15	15	8 330	5.0
Manuherikia Falls, New Zealand	1936	102	17	17	13 800	6.0

* It has been recorded that the saving by constructing the bellmouth shaft and tunnel outlet at this reservoir as against the older weir and waste channel, amounted to £60 000 ($300 000).

In some circumstances there are advantages in adopting other than the circular form for the spillway itself. In the Royd Moor (Barnsley, England) Reservoir, completed in 1932, the weir is five sides of an octagon and is formed adjacent to and incorporated with the valve shaft: from the basin so formed the water falls down a circular shaft.

In the Abberton (Essex, England) Reservoir, now under construction, the spillway required is of moderate length, owing to the large top area of the reservoir in relation to its catchment, and the depth of the reservoir does not exceed 50 ft.; it was convenient, in this case, to form the basin so that

overflow will take place over the two long or longitudinal sides into the river diversion tunnel below, and, in somewhat similar circumstances, at the Eye Brook (Northants, England) Reservoir, about to be commenced, overflow will take place on the four sides of the rectangular basin, and 3 000 c.f.s. normal maximum flood will be discharged with a head of about 3 ft.

To return to the circular spillway: The bellmouth of the Ponsticill Reservoir has six radial ribs or fins which do not project above the crest of the weir; they are struck to a smaller radius than that to which the vertical section of the bellmouth is drawn, and have a maximum projection of 1.5 ft. The four ribs at the Silent Valley are somewhat similar, and, in the light of experiments subsequently made on models, it is not to be expected that either of these spillways will be entirely free from vortex action, though up to the relatively moderate heads under which they will normally operate, it is not anticipated that such action will seriously reduce the discharge.

Experiments with models have been carried out at the Burnhope, Shing Mun and Manuherikia Reservoirs, and the nature of the results obtained serves to emphasize the importance of subjecting to experimental investigation before construction commences not only the bellmouth itself, but, in most cases, the whole of the proposed design of the flood disposal works, i.e. the combination of forebay, weir, shaft and tunnel.

Burnhope Experiments. At Burnhope a 1/24 scale model of the flood disposal works was investigated; various anti-vortex devices were tried out and the conditions of flow at the bend between the shaft and tunnel were examined. The results are to be described in detail elsewhere, but reference will be made to certain experiments.

In Run 25 four equidistant radial piers 3 ft. wide and rising to 5 ft. above the crest of the bellmouth were used; a definite vortex formed at 2.75 in. (5.5 ft.) head on the weir. In Run 23 sixteen similar piers were fitted, with a consequential rise in the vortex point to 3.25 in. (6.5 ft.), which was the maximum head to which this particular series was carried. In Run 44 made with a diametral vertical rib or curtain wall, extending 9 ft. below the crest and 5 ft. above the crest, and with two "eared" ribs or fins on the bellmouth on the other diameter, there was no vortex even at a head of 5.4 in. (10.8 ft.).

The curtain finally adopted was the result of trying out curtains having the top about 5 ft. above the crest of the 50 ft. diameter weir, and the bottom from 22 ft. to nothing below the crest: these trials indicated that the best results were obtained when the bottom was between 9 ft. and 3 ft. below the crest. By continuing the curtain to close the gap between the channel wall and the crest of the weir at its narrowest point, a further improvement was obtained, and in the final structure the curtain extends to 9 ft. below the crest and across the gap down to the floor of the channel. The two "eared" ribs are not really necessary and, indeed, produced an undesirable divergence in the discharge curve between certain heads.

It will be noted that the effect of the substitution of the curtain wall for one of the two pairs of ribs was to increase the discharging capacity at 2.0 in. (4-ft.) head from 1.18 to 1.45 c.f.s., or by nearly 25 per cent.

The results of the three runs are plotted in Figure 2 and it will be seen that they do not correspond in any case to a definite exponential law. The

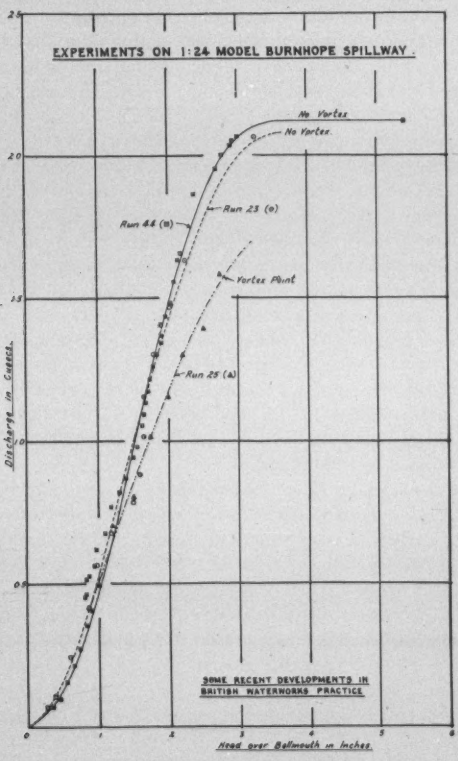


FIG. 2.— EXPERIMENTS ON 1:24 MODEL BURNHOPE SPILLWAY.

feature which is noteworthy is that, beyond a certain limiting head which varies according to the type of anti-vortex arrangement, the discharge does not increase; this makes it necessary to select a design head which lies well within the limits of the steepest part of the discharge curve, so as to leave an ample margin for floods in excess of the normal. A vacuum of small amount was created at the higher discharges at the inside of the bend between the vertical shaft and the tunnel, but it was not considered of

sufficient moment to justify any special provision in the actual structure, though the advisability of studying the behavior at similar bends where higher velocities and consequent less favourable conditions might develop was indicated.

To establish the approximate quantitative effect of entrained air on the discharge, some instructive experiments were carried out at Burnhope. For this purpose the whole of the chamber or forebay containing the bellmouth was sealed by an air-tight cover resting on the side walls: over the approach channel the seal was completed by a vertical diaphragm, the bottom edge of which was just below the water surface and, therefore, imposed no material obstruction to the freedom of approach to the bellmouth.

A water column manometer was attached to the cover and air was admitted to the sealed chamber by previously calibrated nozzles at such a rate as would maintain the pressure within it at approximately atmospheric: the quantity of air supplied was determined by pressure gauge readings on the nozzles: the nozzles were fed from an air receiver, which, in turn, was supplied from one of the works compressed air lines; the flow over the control weir gave the corresponding water discharges. Table 5 gives the results in cubic feet per second.

TABLE 5.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Ratio. Air.	No Anti-Vortex Arrangements.		Burnhope (Curtain Wall and 2 No. Ribs.)		Silent Valley (4 No. Ribs) (on 50-ft. dia. Bellmouth.)		Pontian. 8 No. Piers.	
Water.	Water.	Air.	Water.	Air.	Water.	Air.	Water.	Air.
0.25	....	....	3 720	930	3 240	810	3 500	875
0.5	2 650	1 325	2 650	1 325	2 800	1 400	2 900	1 450
1.0	1 800	1 800	1 800	1 800	2 060	2 060	2 060	2 060
1.5	1 250	1 875	1 430	2 145	1 650	2 475	1 580	2 370
2.0	840	1 680	1 180	2 360	1 330	2 660	1 230	2 460
2.5	560	1 400	980	2 450	1 120	2 800	1 050	2 625
3.0	340	1 020	820	2 460	1 000	3 000	....	....

It will be seen in all cases how, at the greater water discharges, the volume of entrained air becomes less. The advantage of the curtain wall at the greater flows is marked: compare 3 720 c.f.s. for the Burnhope model with 3 240 c.f.s. for the same model but provided only with four radial fins as at the Silent Valley. The head corresponding to 3 720 c.f.s. on the Burnhope model is 3.75 ft., and to 820 c.f.s. it is 1.5 ft.

Shing Mun Experiments. These were carried out to determine the best shape of the bellmouth, the best anti-vortex arrangement, and the advisability or otherwise of making special provision for air vents to prevent the formation of a vacuum at the junction of the bellmouth and the inclined tunnel.

In this case, local conditions made it economical to take the discharge from the bellmouth into the river diversion tunnel by means of a tunnel sloping at about 1 vertically to 2 horizontally; the upper bend between the vertical shaft and the inclined tunnel being of short radius, whilst at the lower bend the radius of vertical curvature was relatively much larger.

The general layout will be clear from the details of the 1:24 scale model given in Figure 3. The experiments indicated that better hydraulic conditions resulted from making the bellmouth more into a straight-sided cone

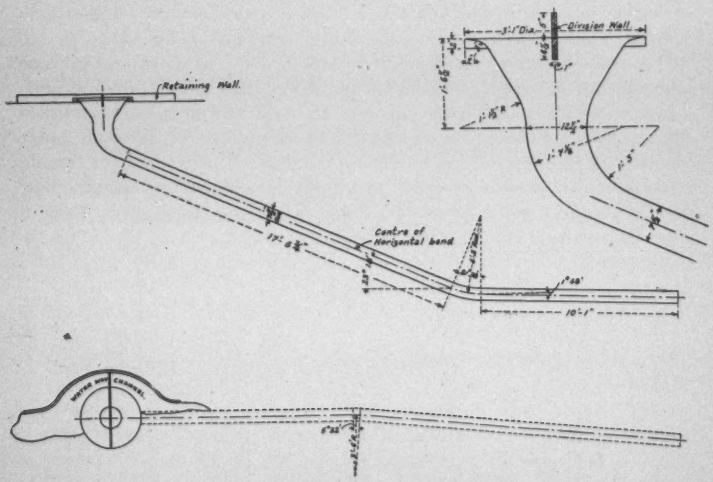


FIG. 3.— PLAN AND LONGITUDINAL SECTION OF THE MODEL OF THE SHING MUN TUNNEL AND BELLMOUTH.
Scale Ratio 1 : 24.

with a base diameter of 25 ft. at the commencement of the upper vertical bend and using this bend of about 30-ft. radius to bring about the reduction to the tunnel diameter of 15 ft. The original arrangement was to have a bellmouth with a vertical arc of a circle such that there was a short length of vertical shaft of 15-ft. diameter preceding a bend of the same diameter, and the alteration to the final form increased the discharging capacity by about 15 per cent. The curtain wall, which proved so satisfactory at Burnhope, was found equally so at Shing Mun: it extends from 3 ft. below the crest to well above flood level, and is continued, as at Burnhope, across the approach channel at its narrowest point.

The Burnhope experiments showed that the absolute pressure fell more or less linearly with increasing velocity of flow, and since the design velocity at Shing Mun was some 45 ft. per second (or about twice the

Burnhope figure) in the 15-ft. diameter tunnel, the experiments included an investigation of the vacuum effects developed at various rates of discharge. In consequence, it was decided that a 24-in. diameter air duct should be formed in the tunnel lining at the crown, with slots at intervals of 18 in. and extending from the beginning of the upper bend to about 80 ft. downstream of the bend. No special provision for aëration was made at the lower bend as the tendency to a vacuum there was of relative insignificance.

The tests on a model incorporating all the elements of the final design showed that a discharge of 14 600 c.f.s. over the 74-ft. diameter bellmouth could be handled with a head of 9 ft. As a normal flood would give a discharge of 8 330 c.f.s. and a head of 5 ft., there is thus a considerable margin to cover extraordinary floods. The top of the dam is 10 ft. above the crest of the spillway.

The reservoir has a natural drainage area of 2 900 acres and in addition the run-off up to 0.4 in. per hour will ultimately be brought in by catchwaters from 7 400 acres. The peak rate of inflow under normal maximum flood conditions was estimated to be 17 400 c.f.s., and this would be caused by a maximum rainfall intensity at the rate of 5 in. per hour, with a total run-off of 18.5 in. in 12 hours from the direct catchment and 4.8 in. in the same time from the indirect catchment, the Hong Kong records indicate that as much as 22 in. of rain may be expected to fall in 12 hours on the catchment area. The corresponding peak rate of outflow is estimated to be 11 330 c.f.s., of which 8 330 c.f.s. will be taken by the bellmouth spillway and 3 000 c.f.s. by a battery of 6 siphons, three of which are arranged to come into action when the head over the bellmouth is 6 in. and the others if the rise in reservoir level should be 12 in. This battery has its own discharge tunnel by which the water is led to flow over the floor of a quarry at a level of 100 ft. above the stream bed and downstream of the tail bay of the river diversion and bellmouth-discharge tunnel; since it is anticipated that the normal floods for which the spillways are designed will occur but once in 50 years, it is not expected that the siphon spillways will be often in action.

The model most used for the purpose of design was to the scale 1 : 29.44, but to investigate the scale effect, models in the proportions 1 : 19, 1 : 24 and 1 : 43.5 were also tested. The larger the scale of the model the closer did the results agree with the $H^{1.5}$ law.

Figure 4 shows the results of a series of experiments on models to the final design with the air-vents in operation. Substantially the same results, so far as discharge was concerned, were obtained when the air-vents were closed, but as has already been mentioned, it was considered necessary to incorporate provision for air venting. The bold black line is the anticipated discharge curve of the 74-ft. diameter weir, its equation being

$$Q = 3.35 \times 223 \times H^{1.5}.$$

Figure 5 shows how the removal of the artificial restrictions in the vicinity of the spillway, i.e. the forebay, channel, floor and wall, increases the discharging capacity. The curtain wall was also absent: had this been

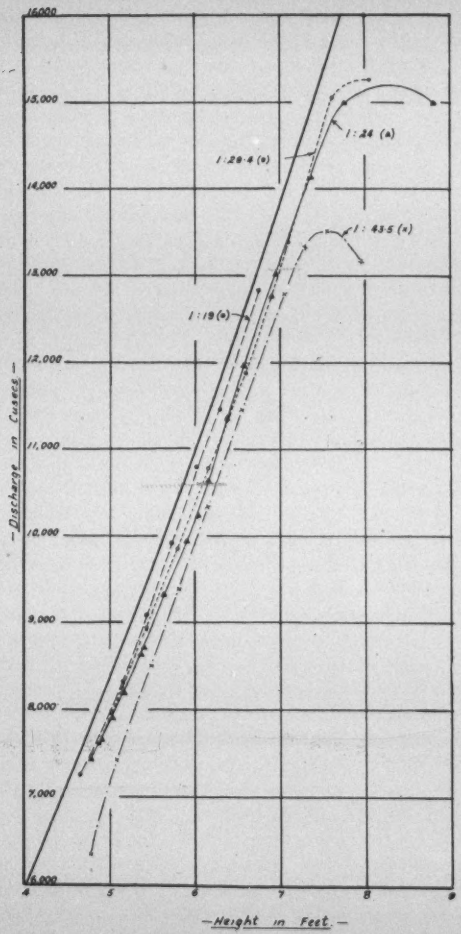


FIG. 4.— DISCHARGE CURVES FOR THE FOUR SHING MUN MODELS. Scale ratios as shown. With waterway channel and division wall. All air vents open.

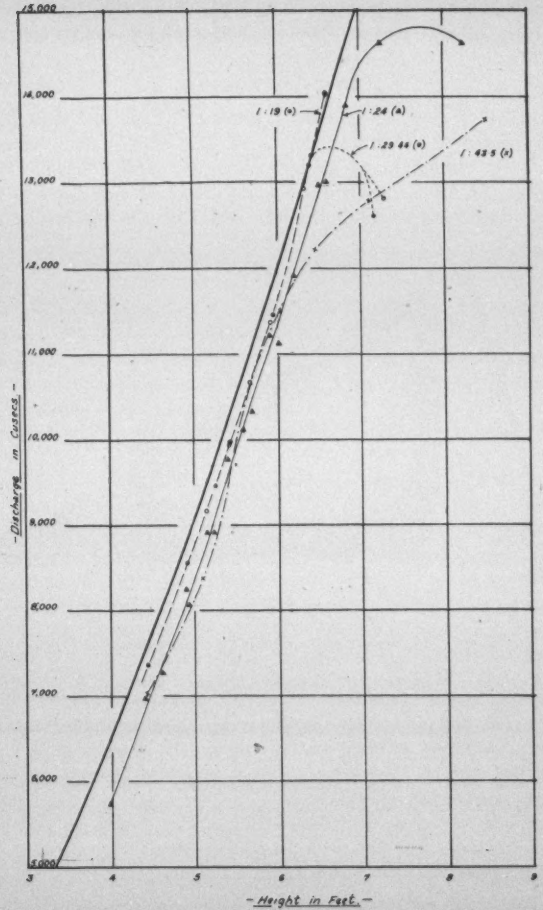


FIG. 5.— DISCHARGE CURVES FOR THE FOUR SHING MUN MODELS.
Scale ratios as shown. No waterway channel or division wall.
All air vents open.

there possibly better results still might have been obtained. The bold black line is the anticipated discharge curve of a 74-ft. diameter weir standing well out in the reservoir, its equation being $3.60 \times 227 \times H^{1.5}$, and this, as compared with the preceding equation, will give almost 10 per cent. greater discharge.

Dam Construction.

Shing Mun Dam, Hong Kong. Although W. J. E. Binnie has quite recently described the Shing Mun Dam in a short paper taken at the World Power Conference at Washington, a few words about it will not be out of place, for it has some features which are novel, and, apart from these, it is believed to be the highest structure of its kind in the British Empire.

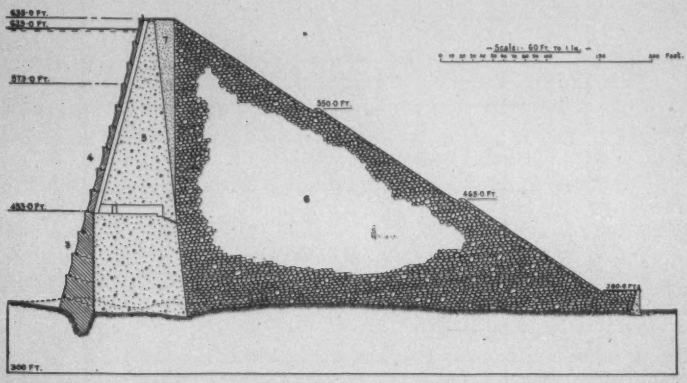


Fig. 6.— Maximum Cross-section of the Shing Mun Dam.

The site is a favourable one in that, although top water level is 265 ft. above the river bed (and 625 ft. above datum), the length of the dam at that level is only 700 ft. The basal rock is grey granite which, though visible in the river bed and up the left bank, lay at some considerable depth, up to 80 ft., over most of the right bank.

As will be seen from the cross-section of Fig. 6 which is taken at the maximum section, the dam is a composite structure consisting of five different portions:

(3) The "cut-off wall" to prevent leakage below or at the sides of the dam, and which is continued above ground level to form the lower portion of the water face.

(4) The "diaphragm" of articulated concrete slabs, which forms the main portion of the water face.

(5) The "thrust-block" which transmits water pressure to the remainder of the dam.

(6) The "rock fill" which takes a portion of the water thrust.

(7) The "sand wedge" which is interposed between the thrust block and rock fill.

The cut-off trench was founded throughout in sound grey granite, free from all but minor faults, and to ensure that these were rendered watertight below the bottom of the trench, recourse was had to exploratory drilling and grouting. The richer concrete—690 lb. per cu. yd. and crushing at 350 tons per sq. ft. at 28 days—of the cut-off was separated from the thrust block by greased paper.

The diaphragm is divided into reinforced concrete panels by vertical joints 25 ft. apart, and by horizontal joints 20 ft. apart, the watertightness of these joints being assured by sheet copper stops 0.1 in. thick. The thickness of the diaphragm at its lowest level—453—is 6 ft., it is reduced uniformly to 3 ft. at 573, and thereafter remains at that thickness. The panels are thus left free to move in relation to one another and, by the interposition of bitumen sheeting, to the supporting buttresses of the thrust block, the faces of which are battered at 1 in 3.72. The only opportunity of testing the diaphragm occurred towards the end of the 1935 monsoon, which, however, ended unusually early and the water only rose to 45 ft. above the base of the diaphragm. As the joints then proved absolutely tight and increasing pressure should decrease the liability to leakage, it is anticipated that the joints will be tight under the full reservoir head.

The thrust block was founded upon the brown granite which formed the upper crust of the compact grey granite: this brown granite was proved to be capable of bearing 500 tons per sq. ft. (as against over 2 000 tons for the grey granite), and was therefore considered an adequate foundation for the thrust block. The buttresses which serve as supports for the panels of the diaphragm are at 12.5-ft. centres, 4.5 ft. wide on the face and project 4.5 ft.; the recess between them forms inspection pits which can be entered from the top of the dam or from galleries formed in the body of the thrust block and approached by steps at either end of the dam. The thickness of the thrust block is 8.5 ft. (over the buttresses) at the top, and at level 453 nearly 80 ft. Watertightness not being necessary, the concrete of the thrust block is not rich—300 lb. of cement per cubic yard with an average crushing strength of 190 tons per sq. ft. at 28 days.

The rock-fill is hand packed in layers 2 ft. thick, and with an inclination of 1 in 12 towards the thrust block; it has an average weight of 109 lb. per cu. ft. The upstream face of the rock-fill is constructed as a rubble wall set in mortar to form the triangular space between it and the thrust block to be filled by the sand wedge, and with provision for the drainage of that wedge. The outer slope is 1.5 horizontal to 1 vertical, and there are berms at 465 and 550 both 10 ft. wide; it ends in a substantial toe retaining wall the top of which is 380. As the records show that settlement has substantially ceased in the lower portion of the rock-fill, it is now being pitched with squared granite hand size pitching 12 in. thick laid in a diamond pattern. The foundation of the rock-fill is the natural ground from which any loose or spongy material was removed.

The sand wedge is primarily designed to transmit to the rock-fill so much of the water load as is not taken by the thrust block, and to ensure that the sand shall at all times have the necessary incoherence to remain in contact with the rock-fill and the thrust block, it was specified that it should be clean and coarse: it is protected against tropical rains by concrete slabbing and supporting reinforced concrete beams resting on the rock-fill and on the thrust block, and provision is made for its drainage through inverted filters into the rock-fill.

The essential feature of the design is the articulated water face designed to prevent the formation of cracks by shrinking of the concrete or due to variations in temperature, and able to accommodate itself to movement under load or caused by seismic disturbance: it was with the latter consideration in mind that the combination of thrust block and rock-fill was adopted in preference to a concrete dam of gravity section.

The main or Gorge Dam of which some details have been given above involves, apart from the valve shaft, spillways and discharge tunnelling, the following approximate quantities:

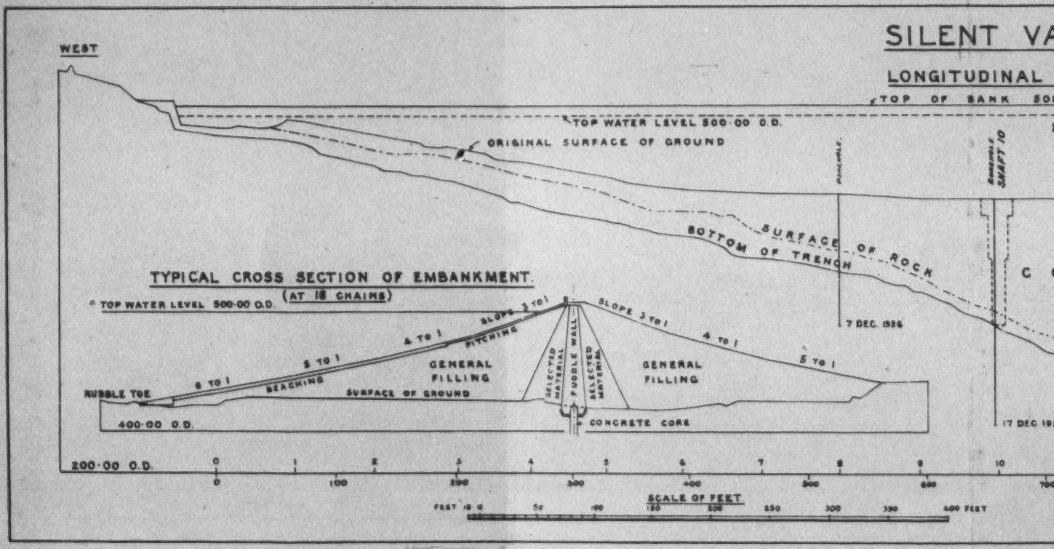
	Cu.Yd.
Excavation — Soft	20 000
Hard	19 000
300-lb. Concrete in Thrust Block	138 000
600-lb. Concrete in Cut-off and to base of diaphragm	20 000
690-lb. Concrete in Diaphragm	9 000
Rock Fill	370 000
Sand Wedge	7 500
	Sq. Yd.
Pitching — 12 inches thick	22 000

The construction of the Shing Mun Scheme was actively commenced in July 1933 and is now rapidly approaching completion.

Silent Valley Reservoir. The completion of the cut-off trench of this reservoir in the face of difficulties, unprecedented at any rate in the British Isles, is a feature of greatest interest to those who have been faced with troublesome deep reservoir trenches. A description of the whole of the reservoir works by the Resident Engineer has been published recently*, but as this may not be generally available in America, a brief account of the further exploratory work and investigations, upon which the final arrangements for dealing with the situation were based, will be given.

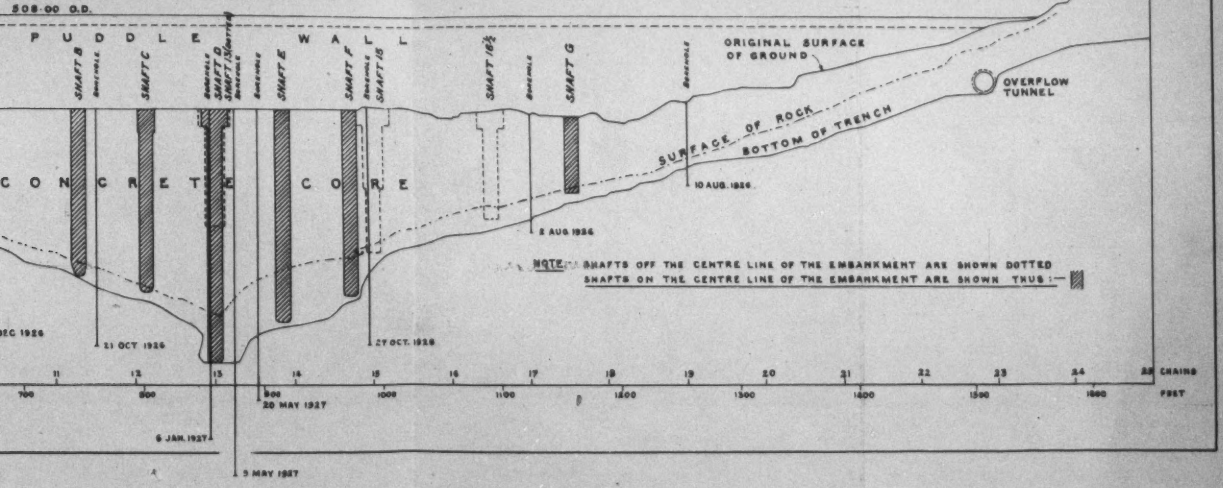
The river having been diverted through a tunnel driven through the solid granite, the excavation of the cutoff trench was commenced and it was found that as the excavation advanced towards the valley bottom, the surface of the rock dipped downwards more rapidly than should have been the case if the information obtained from the preliminary boreholes had been correct.

* The Construction of the Silent Valley Reservoir, Belfast Water Supply. G. McIldowie, Proc. Inst. C. E., Vol. 239.


SILENT VA
LONGITUDINAL
WEST
℄ TOP OF BANK
TOP WATER LEVEL 500·00 O.D.
ORIGINAL SURFACE OF GROUND
BOTTOM OF TRENCH
SURFACE OF ROCK
7 DEC. 1926
17 DEC. 19
TYPICAL CROSS SECTION OF EMBANKMENT.
(AT 18 CHAINS)
TOP WATER LEVEL 500·00 O.D.
SLOPE 3 TO 1
4 TO 1
PITCHING
SLOPE 3 TO 1
4 TO 1
5 TO 1
6 TO 1
5 TO 1
BEACHING
GENERAL FILLING
SELECTED MATERIAL
PUDDLE WALL
SELECTED MATERIAL
GENERAL FILLING
RUBBLE TOE
SURFACE OF GROUND
400·00 O.D.
CONCRETE CORE
200·00 O.D.
0 1 2 3 4 5 6 7 8 9 10
0 100 200 300 400 500 600 700
SCALE OF FEET
FEET 10 0 50 100 150 200 250 300 350 400 FEET

VALLEY RESERVOIR.

AL SECTION OF EMBANKMENT.


508·00 O.D.
P U D D L E W A L L
SHAFT B
SHAFT C
SHAFT D
SHAFT (Shorter)
SHAFT E
SHAFT F
SHAFT 15
SHAFT 16½
SHAFT G
ORIGINAL SURFACE OF GROUND
OVERFLOW TUNNEL
SURFACE OF ROCK
BOTTOM OF TRENCH
C O N C R E T E C O R E
EAST
10 AUG. 1926
2 AUG 1926
21 OCT. 1926
27 OCT. 1926
20 MAY 1927
6 JAN. 1927
3 MAY 1927
NOTE:- SHAFTS OFF THE CENTRE LINE OF THE EMBANKMENT ARE SHOWN DOTTED
SHAFTS ON THE CENTRE LINE OF THE EMBANKMENT ARE SHOWN THUS :—
11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 CHAINS
700 800 900 1000 1100 1200 1300 1400 1500 1600 FEET

It was therefore decided to sink six further boreholes. the positions of which are shown on the accompanying plate and the last of which was completed by the end of 1926 and showed that the rock, instead of lying at a depth of about 50 ft., was actually about 180 ft. below the surface at the deepest part of the valley. These boreholes were sunk with considerable difficulty as numerous boulders, some of great size, were encountered, and it appeared therefore probable that the original boreholes, which were thought to have reached the rock, must actually have terminated in large granite boulders.

Meanwhile, an endeavour was made to sink a timbered shaft for the purpose of dewatering the strata, but this work had to be abandoned as the material penetrated became of such a nature as to run freely with water, entering the shaft as rapidly as it was excavated. An attempt was then made to drive down a circular ring of interlocking steel piles so as to form a sump from which the water could be pumped, but this method had also to be abandoned as the piles could not be driven through the boulders. It became apparent that the work of sinking the trench to so great a depth through material of such a character presented difficulties of a very grave nature, and that the methods envisaged in the original contract were impracticable.

The Contract basis was abandoned and thenceforward the work proceeded on a cost-plus basis under the direction of a Board of Engineers—W. J. E. Binnie, E. Sandeman and H. P. Hill—and twelve months was allowed in which to explore the situation and to advise the Water Commissioners whether it was considered possible to construct a reservoir on this site.

The construction of the embankment and ancillary works presented no special difficulties, but it was impossible to impound water by means of this embankment unless the percolation of water through the permeable material underlying the bank could be prevented, and in order to effect this object it would be necessary to carry the cut-off wall right down to the rock through running sand and boulders. A very large expenditure amounting to about £400 000 had already been incurred on works which would be rendered useless if the reservoir could not be constructed on this site.

If the silt and silty sand which ran freely when saturated with water could be induced to part with some of its moisture, the material would become sufficiently stable to be excavated without difficulty. The only method which promised success was to construct drainage shafts under compressed air, as the pressure of the air would drive the moisture out of the silt and silty sand and prevent the run of material into the shaft. It is not either advisable or practicable to subject men working under compressed air to a greater pressure than 30–35 lb. per sq. in. above the atmosphere, and as the water level in the material stood at a comparatively short distance below the surface prior to the commencement of operations, it was evident that the pressure of air necessary to exclude the water would become too great long before the shafts reached the rock at the centre of the

valley. This difficulty could, however, be overcome if it was found that the level of saturation in the strata could be lowered by pumping, and the following plan of campaign was drawn up.

When the first shaft had reached the depth limited by the air pressure, the work of sinking was to cease: a strainer was to be placed in the bottom to minimise the entry of sand, and pumps were to be installed by means of which water could be withdrawn from the surrounding strata. An adjacent shaft was to be started somewhat later which would reach a lower level before the air pressure became too great, if the pumping at the first shaft proved to be effective in lowering the water level in the strata. When the greatest attainable depth had been reached by this second shaft, the pumps were to be transferred to it and it would then become the pumping shaft. Work under compressed air was then to be recommenced in the first shaft, while the pumping from the second shaft continued to lower the water level in the strata, the sinking of the first shaft being again suspended when the maximum air pressure had been reached, and so on.

By adopting this procedure it was hoped that the water level in the strata would gradually be lowered sufficiently to permit of the rock being reached.

As this method promised success, four shafts were sunk, lined with cast iron and spaced at intervals adjacent to the centre line of the embankment, the positions of these shafts being shown in dotted outline on the section of the Plate. Two additional boreholes were also put down to endeavour to locate the lowest level of the surface of the rock in the pre-glacial valley, as it was desirable that one of the shafts should be sunk at this point to ensure the drainage of the glacial material right down to the bottom.

Work proceeded on the lines indicated above during the year 1927, and, by the end of the year, the Board were able to inform the Commissioners that they were of opinion that it would be possible to construct the reservoir on this site. It was recommended that instructions should be issued authorising the excavation of the trench, and in June, 1928, a scheme was put forward to sink six further shafts 11 to 12 ft. in diameter and spaced about 56 ft. apart, which are lettered B to G on the section.

These shafts are situated on the centre line of the cut-off trench, and were to act first as drainage shafts to de-water the trench, and were afterwards to be filled with concrete to form part of the "cut-off" wall, a portion of the cast iron lining being removed so that the concrete was continuous throughout the length of the trench. It was further decided to line the trench, where over 100 ft. in depth, with cast iron segmental plates, in general 18 in. deep but in very bad places 9 in. deep, held apart by timber struts, and connected to the shafts at each end, the struts to be removed as the concrete was brought up. The silt exercised a pressure equivalent to that of a liquid having a density of 100 lb. per cu. ft., so it would have been

impracticable to line with timber in the ordinary way, as insufficient space would have been left for raising and lowering the skips.

The cast iron plates were also of great advantage in other ways, as they avoided spaces through which sand could run and facilitated the injection of grout into the material behind the plates, which was found to have a considerable effect in reducing the rate at which running sand entered the trench, and also filled any cavities which were formed behind the plates. Altogether some 3 000 cu. yd. of material entered the shafts or the trench simply through blows, which indicates the nature of the material in which the work was carried out.

Instructions were received to proceed with this work, which was accordingly commenced in June, 1928, and the last of the shafts—which was 211 ft. in depth—was completed in June, 1929, having penetrated about 30 ft. into the rock, the surface of which was soft and decomposed. It was found that the boreholes had predicted the position of the bed of the preglacial stream with accuracy, as this shaft was sunk at the exact spot.

Meanwhile, work on the trench proceeded rapidly till the water level was reached, below which considerable difficulty was experienced owing to the running sand; the excavation for the trench, except for a short length where the river crossed it, being completed by the end of October, 1929, and a good rock foundation secured right across the valley. The concreting was practically finished by the middle of 1930.

It is a curious fact that the quantity of water pumped from the strata remained nearly constant at about 1 200 000 to 1 400 000 gallons per diem throughout the whole period of trench excavation, becoming less as concrete refilling proceeded.

Had the initial investigations been of a more complete character, so that the cost of overcoming the difficulties of the site could have been estimated, it is probable that every effort would have been made to locate a more suitable site. But, as explained previously, a considerable expenditure had been incurred before the grave uncertainties of the position became apparent: that the work was eventually successfully completed is a tribute to the Contractors and to the Board of Engineers under whose direction it was carried out.

Conclusion

It is realised that there are other important subjects deserving of mention in any review of recent developments in the waterworks field. It is, however, anticipated that in future interchange papers, British authors will in their turn give the Association the benefit of their views on matters with which they have been particularly concerned.

Discussion.

Robert E. Horton.* Mr. Gourley's comprehensive paper touches a number of interesting points. The importance and value of comparing notes and experience as between workers in the same field but whose work is in different localities and under different conditions can hardly be overestimated. The New England Water Works Association is to be congratulated on having so distinguished a member of the engineering profession as its guest at this meeting and in having so able a paper as that presented by Mr. Gourley for discussion and inclusion in its Journal.

Protection of Underground Water. The first topic discussed is the protection of underground water supplies against diversion. The common law in the English-settled portion of eastern United States regarding this matter is founded upon the English law and court decisions and is essentially the same — the landowner has no exclusive rights in diffused groundwater in his land. Undoubtedly the common law in this matter was crystallized at a time when there was little danger of important invasion of another's rights by withdrawing groundwater from adjacent land, and the common law is probably based on the general principle — applicable also to surface streams and to other matters — that there is a common right of use of air and water for ordinary domestic or individual purposes and that a landowner may not enjoin his neighbor in such necessary individual use because his own use might easily affect others in the same way. Conditions change and larger developments of natural resources bring about results not contemplated. For example, this interpretation of the law regarding underground water has also been applied to oil and has created great economic waste. Obviously where large supplies are drawn from groundwater, particularly from the surface or non-artesian aquifers, either for municipal industrial use, the volume and availability of groundwater supplies for other users may be seriously affected over considerable areas. This situation can be cured, as in the United States, by special legislation, in a manner similar to that described by Mr. Gourley, by the insertion of protective clauses in Parliamentary Bills permitting the taking.

Mr. Gourley states that under such protective clauses in England, damages may be recovered if they can be shown to exist within a fixed radius of the well or well field. This, it seems, raises an important question and suggests a field of activity for engineers which has not hitherto received the attention it deserves. Probably most hydraulic engineers, accustomed to the usual methods of computing the yield of wells, are predisposed to think of the area affected by the withdrawing of water from a well or well field as more or less circular and definitely limited.

Consider, for example, the surface aquifer in its natural condition in a moderately sandy or permeable region. Under natural conditions the aquifer extends from the phreatic divide — which may or may not be coin-

*Consulting Hydraulic Engineer, Voorheesville, N. Y.

cident with the topographic divide—to a stream or outlet. Obviously there must be an outlet for underground water under natural conditions, otherwise the water-table would rise to the surface. Now suppose a well field is established, for example, not far from the stream. It can readily be shown that under the conditions described, the area affected by withdrawal of water is not even approximately circular. The form of the well field can be expressed by the equation of a curve, and its form somewhat resembles a parabola or a long, narrow rectangle, with the downstream end between the well field and the outlet stream, and this end is rounded. As a rule the longer axis of this area is parallel with the direction of groundwater flow. Wells even at a relatively small distance on either side of this axis may not be affected by the well field, whereas groundwater levels, even at a considerable distance upstream, may be affected and, in turn, new wells put down anywhere in this well field will affect the water level in the original wells. Furthermore, the extent of the well field increases with the rate of withdrawal of water and varies with the time of year, that is, with the relation between accretion to the water-table and the rate of withdrawal.

There is another point to which I think attention has not hitherto been drawn. In relatively flat sandy areas underlain by aquifers there may be no impermeable divide between two adjacent aquifers, one flowing, for example, down a slope facing eastward, the other flowing down a slope facing westward. Withdrawal of large quantities of water from the easterly aquifer tends to move the phreatic divide to the west, thus encroaching on the westerly aquifer and affecting the groundwater supply of a stream wholly different from the one to which the wells are adjacent. It would seem that instead of adopting a fixed radius in case of withdrawal of waters from surface aquifers in permeable deposits, a comprehensive phreatic survey should first be made to show the boundaries of the aquifer and, second, a hydraulic study should be made of the effect of pumping from the proposed well field, to determine as nearly as possible the boundaries of the well field itself, including, among other things, the possibility of shifting of the phreatic divide as a result of pumping, and consequent damage in the adjacent aquifers.

It is neither impossible nor difficult to plot the lines of flow of a well field in a manner somewhat similar to that in which the field of a magnet is plotted and there are now available electric methods by means of which the boundaries and lines of flow can be determined with considerable accuracy by means of models. The matter becomes more complicated if the terrain in which the aquifer is located is not homogeneous.

Of course the methods which have just been proposed for such problems are advanced, in the sense that they are not at present in general use. There is another reason why such methods should be more generally known and used. In some cases municipalities using groundwaters have sought to protect their sources of supply by the acquisition of large tracts of land supposedly comprising the well field. At least one instance has come to the

much larger capacity for use of water is now commonly installed in conjunction with hydroelectric plants than was formerly the case. Compensation on the basis of use by the waterworks of waters in excess of those used or required for power production would therefore often leave so little available as to make the water supply use unfeasible. Still, there seems to be a reasonable basis of operation which will permit the use of streams in the most advantageous manner, that is, by joint regulation of the stream by construction of reservoirs to be used both for power and water supply and perhaps also for other purposes, such as flood control and, in some instances, irrigation. Suppose, for example, the conditions are such that with reasonably complete regulation the water required for domestic uses can be obtained from one-half of the run-off, leaving the other half available for power production or other uses. Then, as compared with an unregulated stream, the effect would be considerably to diminish the amount of power available but at the same time greatly improve the character and value of the power by changing the situation from that of development of energy on a run-of-the stream basis, with relatively little firm energy, to a basis where all or nearly all the energy could be produced as firm demand energy, worth several times as much per kilowatt-hour as in the first instance. The power owners could in many instances well afford to enter into an agreement of this kind for joint regulation of a stream in spite of the diminished total energy which they would produce after diversion takes place. Even if all of the burden of constructing reservoirs was borne by the divertor, it may happen that the cost would neither be prohibitive nor perhaps as great as if he took the water rights by condemnation and paid for them in cash. Furthermore, there is a general principle which should not be overlooked in the development of public water supplies and that is that the development should be carried out in such a manner as to cause a minimum of economic loss to the community. If the taking of a water supply from a drainage basin can be carried out in such a manner that it redounds to the economic advantage of the community in other respects as well as in the matter of better water supply, the results will be doubly beneficial.

Recently the United States Supreme Court has authorized the diversion of water from an interstate stream, namely, Delaware River, on the basis of a modified form of compensation in kind. Apparently the decision of the Supreme Court does not preclude riparian owners below the point of taking, either within or outside the state in which the diversion is made, from recovering whatever damages can be shown. Furthermore, the terms of the decision are by no means definitely fixed. They provide for an initial taking of 90 m.g.d. from one tributary of Delaware River in New York State, on a basis which requires the divertor to maintain in the stream a relatively small proportion of the total flow. The case is, however, left open for further adjudication after this plan has been tried out, and the Master's opinion contains a significant statement to the effect that when the larger diversion proposed is undertaken, a different plan of compensation may

be required, even to the point of requiring the divertor to construct large independent reservoirs to maintain a regulated flow in the river below the point of diversion.

Mr. Gourley describes an interesting "characteristic" which he has developed for determining the variability of a stream. This calls to mind another compensation agreement. In connection with the taking of a new water supply from Spruce Creek for the city of Little Falls, N. Y., many years ago, an agreement was entered into between a power owner and the city to the effect that the city would be permitted to divert as much water as it required for its then proposed supply upon condition that it build impounding reservoirs sufficient so that the "natural and normal" flow of the stream, exclusive of storm-water, could always be maintained unimpaired below the point of diversion. Many years of litigation ensued, mainly over the question as to what constituted "natural" and "normal" flow of a stream. While the case was finally settled out of court, the Supreme Court judge before whom the matter was heard, after hearing much evidence by experts on both sides, fixed upon a quantity as representing "natural" and "normal" flow which was not far from and was apparently intended to represent about that portion of the total run-off which was supplied to the stream, on the average, from groundwater flow. Spruce Creek has a sandy drainage basin and a large part of the total run-off is groundwater.

There has long been need for some numerical characteristic which would describe the uniformity of regimen of a stream. There are various statistical characteristics, such as the coefficient of variability of annual run-off, but the physical meaning of these is not at once obvious. The characteristic suggested by Mr. Gourley is the ratio of the average daily flows on days when the flow was not greater than the mean, to the mean flow. It may be noted that this characteristic necessarily bears a close relation to the ratio of groundwater flow to total run-off. Streams are perennial if and only if their flow is sustained during rainless periods by some form of storage. This may be either storage in the stream channels, storage in natural or artificial lakes or reservoirs, or groundwater storage. In case of many streams, groundwater storage is far the most important in sustaining continuous flow. Natural lakes, if too extensive in proportion to the drainage area, may have the opposite effect by causing a loss through evaporation in dry periods greater than the coincident supply and hence permitting no run-off to take place below their outlets. It is possible by methods now available or which are being developed, to make a reasonably good separation of surface run-off from groundwater flow of a stream. When such methods are perfected and become more generally available, the ratio of the groundwater flow to total run-off or, in some cases, the ratio of the outflow derived from storage in all forms, to the total run-off, would appear to be the best possible "characteristic." Until then the "characteristic" suggested by Mr. Gourley can be more readily applied and perhaps defines

With reference to the Fuller formula, which involves the average annual flood as a major independent variable, criticism has been made on the ground that it requires an exceedingly long flood record to give a definitive or invariant value of the average annual flood. That this is true is illustrated by the figures on page 379, showing values of the average annual flood, compiled for periods of different durations, from the 31-year flood record of Connecticut River at White River Junction, Vt.

The table shows, for example, that this record contains 22 10-year periods and that the average flood as determined from a 10-year record on this stream ranges from 48 480 to 60 920 c.f.s. This range is so wide as to make the 10-year average annual flood of little use as a statistical datum in the study of flood data.

The number of reliable flood records of more than 25 to 50 years' duration in the United States is relatively small. It is necessary to have some figure as a datum of reference in the analysis of flood magnitudes. It is suggested that the use of what may be termed the "average flood" instead of the average annual flood meets this requirement better than the latter. The average flood may be defined as the average of all floods which exceed the lowest annual flood, the annual flood being the highest discharge of a given year. The use of average instead of annual floods provides usually two or three times as many data, with a record of given duration, as the use of annual floods and hence greatly shortens the necessary length of record to supply a nearly invariant value of the average.

There is apparently a definite relation between the average flood and the average annual flood. This relation seems to be quite nearly constant but is probably affected by the regularity of the stream and so is related to a regimen factor, such as that proposed by Mr. Gourley. Until further studies have been completed, the only rule that can be given is that the average annual flood on medium sized or relatively large drainage basins appears to be about 1¼ to 1⅓ times the average flood.

Caleb Mills Saville.* It is a privilege much appreciated to be invited to discuss the subject "Compensation" of the paper presented by Mr. Gourley of that distinguished firm of English Civil Engineers, Binnie, Deacon & Gourley. One of the founders, Mr. George F. Deacon, made the masterly report on the construction of the Vyrnwy Dam of the Liverpool Water Works, that, so far as the speaker knows, described pioneer work in masonry dam construction which has since become standard practice. Mr. Deacon also wrote that very instructive article on "Water Supply" appearing in Encyclopaedia Britannica (11th Ed.) which may be ranked to-day among the beacon lights of the literature of that subject. Another of the founders was the late Sir Alexander Binnie, author of the classical report on rainfall,† which has served as a guide in later investigations and which is most highly considered and greatly used at the present time.

*Manager and Chief Engineer, Water Bureau, Hartford Metropolitan District, Conn.
†Proc. Inst. Civil Eng. 100 (1892).

Without knowledge of facts extending over a great number of years, it would seem impracticable to formulate coefficients that would or could be satisfactory under the varying circumstances and combinations of river use in the United States. Conditions here are so different from those in the British Isles that one's experience and judgment can hardly compass some matters which are of importance there. For example, the matter of fishing rights is rarely considered here and many other recognized rights by prescription there are only vaguely known in this country, as relics of the old English law, on which, however, our New England common law is founded, a foundation which, God grant, may never be taken from us for that of "lesser breeds without the law." In the ancient days in America, streams were so many and fish so plentiful that it seemed unnecessary to hold back anyone in the new country. So custom, in that as in other things, while generally responsive to English practice, broadened the scope, until in some matters, the base is hardly recognizable. I regret to state, however, that this disregard of natural resources by the fathers in the early days is now being visited upon the children to the extent that in many matters, it is becoming increasingly difficult to repair the injury to public welfare caused by the looser conception of Nature's limitations.

The United States Constitition declares (Article V, Amendments) " . . . nor shall private property be taken for public use without just compensation," and in the Constitution of the State of Connecticut (Article I, Section 11) it is stated: "The property of no person shall be taken for public use without just compensation therefor." Compensation has been held by the courts of this nation to be payment in money for full value of the property taken at its highest value for any reasonable use. In the East, the principles of English common law govern; in the West, "prior appropriation" is the usual basis for settlement.

Referring now to eastern practice only: The language of Chancellor Kent* on riparian rights, which is the basis of common law in this country and England, states: "Every proprietor of lands on the banks of a river has naturally an equal right to the use of the water which flows in the stream as it was wont to run (*currere solebat*) without diminution or alteration." Under present conditions of population and advance in civilization, there are many things which interfere with a rigid interpretation of the rule enunciated by Kent many years ago, and while the basic principle remains, the law, not being an exact science, must construe in accord with common sense at the time of opinion. The right of *all* riparian proprietors, however, to have usufruct of the streams† for their legitimate purposes is fundamental, of which they may not be deprived whether or not they use those rights at the time diversion is attempted.

*3 Kent Comm. 439; Black "Law of Water Rights," Sect. 8, p. 11 (1893).

†"Aqua currit et debet currere" is the legal statement.

TABLE 6.— RAINFALL AT RESERVOIR NO. 1, WEST HARTFORD.
1836–1935 (100 Years).

Minimum Rainfall — Consecutive Period Years.

No. of Consecutive Months.	Date of Period.	Average 12 Months Rainfall — Inches.	Per Cent. of Average Annual Rainfall.
12	Aug., 1837–Jul., 1838	28.38	65
24	Oct., 1879–Sep. 1881	34.25	79
36	Sep., 1879–Aug., 1882	33.98	78
48	Sep., 1879–Aug., 1883	34.71	80
60	Jan., 1879–Dec., 1883	35.72	82
120	Oct., 1874–Sep., 1884	38.06	88

Minimum Rainfall — Consecutive Calendar Years.

No. of Years.	Years.	Average Yearly Rainfall — Inches.	Per Cent of Average Annual Rainfall.
1	1935	28.90	67
2	1930–1931	34.94	80
3	1881–1883	35.86	83
4	1880–1883	36.12	83
5	1879–1883	35.72	82
10	1875–1884	38.74	89

For purposes of comparison of water loss from streams in southern New England with that under English conditions, the following data are presented:

	Average Rainfall Years of Record. Inches.	Average Water Loss Years of Record. Inches.	Per Cent. Loss.
Nepaug	43.68	21.59	49.4
East Branch	43.67	16.47	37.7

	Average for 3 Lowest Years. Date.	Inches.	Water Loss 3 Lowest Years. Inches.	Per Cent. Loss.
Nepaug	1929–31	38.72	22.54	58.2
East Branch	1914–16	38.99	12.61	32.4

The wide difference in water loss; nearly ten inches in the low years and 5.12 inches for the average,* with complementary increase in yield, is an indication of difference in watershed characteristics and evidence of the futility of averages when physical conditions are involved. These two watersheds are only thirteen miles apart.

The geological formation of both of the Connecticut streams, "Nepaug" and "East Branch," is a country rock of gneiss and schist overlaid with glacial deposits of varying character. The Nepaug valley is roughly oval in form with somewhat gradual slopes, while the East Branch valley is long and narrow, with steep slopes. The valley floor in each case is more or less cultivated meadow, while the slopes are pasturage or wooded. The flow in the two streams differs considerably; that in the Nepaug being better sustained due to valley deposits, while that of the East Branch is of a more

*Nepaug and East Branch.

torrential character, the effect of which seems to result in lesser water losses from evaporation from soil and vegetative cover.

For the "user" coefficient, the Committee based its judgment somewhat on present conditions and suggested coefficients applicable to four classes of streams; 0.35, 0.46, 0.58 and 0.70, from the least- to the most-industrialized stream. The development of the characteristic "K" is given in Tables 1 and 2 of Mr. Gourley's paper. For purpose of comparison with conditions in Southern New England, a table compiled from the Nepaug data is presented herewith. Note that gallons in this table are U. S. gallons (0.833 Imperial Gal.).

From Table 7, it appears that the character of the streams in the British Isles and in Southern New England are not greatly different.

TABLE 7.— COMPUTATION FOR CHARACTERISTIC "K".—Four Year Group.
Analysis of Nepaug Flows. ("English" Period.)*
Area of Watershed; 23.9 Sq. Mi. Run-off: Average† Annual, 22.09 in.; Maximum (120), 33.92 in.; Minimum (1930), 11.45 in.

1	2	3	4	5	6	7	8	9
Four Years Ending Sept. 30.	Total Flow m.g.	Max. Daily Flow m.g.	Min. Daily Flow m.g.	Av. Daily Flow (4 yrs.) m.g.	No. Days at or Below Average.	Total Flow During those Days m.g.	Av. Daily Flow those Days m.g.	Characteristic Col. 8. / Col. 5.
1926	34 098	604.3	1.8	23.3	1 025	9 219.4	9.0	.386
1927	35 145	604.3	1.8	24.1	998	10 340.2	10.4	.432
1928	39 410	726.4	1.8	27.0	974	12 143.3	12.5	.463
1929	41 251	726.4	1.0	28.2	911	12 426.3	13.6	.482
1930	39 201	726.4	1.0	26.8	925	12 196.6	13.2	.493
1931	35 272	726.4	1.0	24.1	943	9 454.5	10.0	.415
1932	25 579	255.2	1.0	17.5	1 047	6 817.1	6.5	.371
1933	27 234	322.6	1.0	18.6	1 057	6 983.4	6.6	.355
1934	30 042	322.6	0.5	20.6	1 079	7 544.8	7.0	.340
1935	31 912	448.4	0.1	21.8	1 043	8 287.4	7.9	.362
Mean	33 914	546.3	1.1	23.2	1 000	9 541.3	9.7	.410

*"English" Period — 1922–1935, incl.
†Average for years of record — 1913–1935, incl.

AVERAGE CHARACTERISTICS.

Streams.	Average Area Sq. Mi.	"K"	Period — Years.
Brenig	15.5	0.393	4
Thames	3812	0.517	6
Nepaug	32	0.410	4
East Branch	62	0.418	4
East Branch	62	0.415	6

For the purpose of comparing yields from several catchment areas during the dryer periods, the characteristic "K" seems to be admirably adapted.

There is some question in the writer's mind, however, whether the period used in the "Brenig" example is of sufficient length, due to varying conditions of weather in different localities even a comparatively short

In his statement, Mr. Gourley refers to the fact that compensation in kind by means of "compensation water," is the exception in the United States. It so happens that in the development for water supply of Hartford Metropolitan District (Conn., U. S. A.), this method has been used.

The amount of water decreed to be let down the stream for riparian proprietors is "Assessment Water," multiplied by the "user" coefficient.

The results obtained by the method proposed by the Technical Sub-Committee, applied to the "Nepaug" stream, is given below, assuming a "user" factor for a highly industrialized stream, and K, R and L, the factors applying to the Nepaug watershed; that is, $U = 0.7$, $K = 0.41$, $R = 43.67$ in., L = Rainfall—Run-off = $38.72 - 16.18 = 22.54$. Formula $A = U\,K\,(0.8\,R\text{-}L)$. The compensation flow; *i.e.*, $0.7 \times 0.41 \times (0.8 \times 43.67 - 22.54) = 3.56$ in. for the flow to be let down for riparian owners on this stream. The average run-off for the three dry years was 16.18 in. The compensation flow, therefore, is about 22 per cent. of the run-off, or 0.26 c.f.s. per sq. mile, which is much less than that in the Hartford settlements, the conditions of which, however, happen to be exceptional.

In 1911, when the City of Hartford diverted 32 sq. mi. of the Nepaug stream from the Farmington River, it was done by agreement with riparian owners below, ratified by the State Legislature, by the building of a 3-billion gal. (U. S.) reservoir on the East Branch of the Farmington River, about 3¾ miles north of Nepaug for the use of and operated under the direction of the riparian owners and "never" to be taken for water supply.

This "Compensating" Reservoir, so-called, had a catchment area of about 62 sq. mi. Several years ago, it was found that the Nepaug source was becoming inadequate and negotiations were begun with the riparian owners to divert about 51 sq. mi. of the catchment area above the "Compensating" Reservoir. These negotiations reached a mutually satisfactory conclusion, and extensive works — dam 140 ft. high with reservoir of 30 billion gal. (U. S.) storage — are now under way.

The basis of the negotiations was permission to use "flood" flows, "flood" flow being defined as the quantity flowing in river in excess of 2 c.f.s. per sq. mile catchment area above the dam during period of construction and filling. After the work is completed, a stated quantity of water annually is to be allocated to the riparian owners, and becomes a first charge on the development. The proposed present diversion includes 32 sq. mi. Nepaug and 51 sq. mi. East Branch catchment areas. Riparian owners' water will be supplied from the developed sources of the Metropolitan District until the need of the District will encroach on the amount allocated to the riparian owners. Before that time, the agreement calls for additional "compensation" reservoirs for storage. The Farmington River below the point of diversion is a highly developed industrial stream, there being fifteen water power plants concerned, with a total fall of about 300 ft.

As to the "User" coefficient; in United States practice, other matters as well as quantity of water would have to be taken into account in assess-

ment of damages, many of which are of such real, if intangible, value, that it would seem impossible to include them in any formula, whether used for power only, or for such purposes as bleaching and dyeing where quality of water is concerned and diminution of flow may affect the water adversely — and both of them might be on the same stream. Diversion, also, may affect the plant in its mechanical equipment. Mr. Gourley's paper deals with only one of the several phases of "compensation" which must be considered in this country; namely, "quantity" of water. Beside, we have "quality" deteriorated by abstraction, and severance; *i.e.*, effect of diversion on mechanical equipment of the plant and curtailment of output, making necessary the retirement of some or reconstruction of other machinery. It seems hardly possible to collect all of these into a single coefficient. Therefore, in view of these considerations, cash settlement seems more generally applicable to conditions in this country, making "compensation in kind" as stated by the author, an exception to the general rule of procedure.

It has occurred to the writer that "Compensation," as the term may be used in England, refers solely to an amount of water to be replaced in lieu of that diverted, and while the amount itself; say one-third of the available flow, may seem small, the fact that it can be delivered at times when most needed would compensate for loss in other ways, if such is the case. Likewise, damage to property by diversion other than reduction of power may be considered in a different category.

In addition to "quality" and "severance" damages, there is also to be considered the relationship of the area of the catchment basin diverted to the total area tributary to the power site. In the case of the Nepaug diversion, with a catchment area of 355 sq. mi. at the upper power, the diversion was 7.6 per cent., while, at the power some thirty miles downstream, with a catchment area of some 590 sq. mi., the diversion was 5.4 per cent.

In this country, compensation is used in an all-embracing sense and covers all damage sustained by the diversion.

In submitting this discussion on Compensation, I wish to congratulate the NEW ENGLAND WATER WORKS ASSOCIATION in being able to obtain this very interesting and instructive paper from Mr. Gourley. I also desire to echo his suggestion that "there should be periodic exchange of papers" between the Institute of Water Engineers (England) and the NEW ENGLAND WATER WORKS ASSOCIATION (U. S. A.), a proposition which if carried out, would be of mutual advantage.

MALCOLM PIRNIE.* Many important American waterworks problems have been revealed most effectively in the independently generated light of recent developments in British waterworks practice so clearly outlined for us by Mr. Gourley. That part of the paper entitled "Underground

*Consulting Engineer, New York, N. Y.

Rainfall. Inches.	Number and Per Cent. of Rains which Were Equal to or More than Stated Amounts.					
	19 Months.		12 Drought Months.		7 Wet Months.	
	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.
			Rains.			
...	72	100.0	46	63.9	26	36.1
			Rainfall.			
.07	72	100.0	46	100.0	26	100.0
.20	57	79.2	37	80.5	20	77.0
.50	43	59.7	27	58.7	16	61.5
.59	38	52.8	23	50.0	15.5	59.6
.68	36	50.0	21.5	45.8	15	57.7
.90	27	37.5	14	30.4	13	50.0
1.15	23	32.7	11.5	25.0	12.4	47.7
1.47	20	27.8	9	19.6	11	42.3
1.53	18	25.0	8.3	18.1	10	38.5
2.17	12	17.4	6.3	13.7	6.5	25.0
2.42	11	15.3	6	13.0	5	19.2
4.00	3	4.2	1	2.2	2	7.7

Precipitation on consecutive days was recorded as one rain.

The table shows that half of the rains in the drought, total, and wet periods considered gave precipitations equal to, or greater than, the following amounts: drought, 0.59 in.; total, 0.68 in.; wet, 0.90 in. Further, that one quarter of the rains gave precipitations equal to, or greater than, the following amounts: drought, 1.15 in.; total, 1.53 in.; wet, 2.17 in. Finally, that another quarter of the rains gave precipitations equal to, or less than, the following amounts: drought, 0.27 in.; total, 0.20 in.; wet, 0.15 in.

Obviously in Florida a precipitation of less than 0.30 in. during a single rain contributes practically nothing to run-off and ground water replenishment. If it is assumed that a precipitation of at least 0.60 in. is required in a single rain to be effective in water production it follows that half of the rains in the twelve months of drought were ineffective for this purpose. In these circumstances the median water-production rain would be 2.17–0.60 or 1.57 in. for the wet period or nearly three times the corresponding 1.15–0.60 or 0.55 in. for the drought period. The conclusion is inevitable, that the proportion of the rainfall available for water production in Florida is directly proportional to the precipitation per rain above a certain minimum. The minimum here assumed is sufficient to saturate only a three-inch depth of the fine surface sand where rapid evaporation and transpiration take place after rain has ceased.

It would be more instructive to apply this method of analysis to the 40-year record of the percolation gauge in the southeast of England than to records from a brief period of 19 months available for this study in Florida.

KARL R. KENNISON.* Mr. Gourley calls attention to the difficult problem in England, with its great density of population, of meeting increasing demands on regional water supplies.

Such problems of supplying a large area, of highly concentrated urban population, have been met in several instances in this country. Two noteworthy examples of regional surface supplies developed by and for a group of municipalities are the water supply of 20 municipalities centering about the City of Boston in Massachusetts on the Atlantic Coast, and that of 13 or more municipalities centering about Los Angeles in California on the Pacific Coast. This method of development by Metropolitan Districts originated, I believe, in Massachusetts where on account of the high concentration of population the individual cities and towns found themselves unable satisfactorily to take care of their requirements, not only for their water supply but also for the disposal of their sewage. In the development of the District, it was found advisable to make a common development also of recreational facilities so that in the area about Boston there have been, since the year 1898 when the movement started, three distinct branches of the Metropolitan District development, the water supply, the sewage and the park system.

As to density of population, the average for the 20 cities and towns is now about 9 000 per sq. mi.,† one of the cities, Somerville, having about 25 800 per sq. mi., whereas on the Swift River drainage area taken for the District's most recent development, there were living only 21 people per sq. mi.

Mr. Gourley refers to the fixing of the regional limits of such a district. The limits of the Boston district are arbitrarily fixed along the lines of political subdivisions. However, the district idea has spread to other fields than water supply, where the limits are solely topographical and geological. For example, the state legislature provides the machinery for organizing districts for the improvement of swamp lands and mosquito eradication.

In the development of water supply districts, those cities and towns whose needs are the greatest are incorporated in the original organization and legislative provision is made by which other cities and towns lying within the specified limits may exercise an option to join whenever they feel that their needs require it. This system of water supply has worked very satisfactorily in Massachusetts where a population of about 1 550 000 residing within a radius of about 10 miles of the State House is supplied through a system of aqueducts extending to the watersheds about 70 miles inland. The District maintains the necessary system of distribution, including some pumping so that, in general, each member municipality receives water at the pressure necessary for delivery to the consumer. These municipalities are assessed the entire fixed and maintenance charges as a part of their annual state tax. The cost is proportioned to the different

*Assistant Chief Engineer, Metropolitan District Water Supply Commission, Boston, Mass.

†Omitting five outlying municipalities which take only 2½ per cent. of the water, the average is 11 200 per sq. mi.

extending over 16 years of the Swift River at Bondsville, kindly placed at my disposal by Mr. E. Sherman Chase, I calculate the average characteristic to be 0.49: this on a drainage area of 192 sq. mi. points to a considerable equalization of flow due, doubtless, to the thickly wooded slopes and to a well-sustained low flow — the minimum being 0.19 c.f.s. per 1 000 acres as compared with 0.107 c.f.s. for the Thames. In closing these remarks, I would like to repeat what is stated in the Paper — that in the ten streams investigated by the Committee, the characteristic varies from 0.32 to 0.48.

Compensation has only been discussed qua quantity: if the stream in question is one of several tributaries, this factor would not be overlooked in assessing a reasonable quantity of compensation: if the effect of abstraction or discharge of "bottom" water as compensation will have other detrimental effects, then, as Mr. Saville pertinently observes, probably the cash basis is more applicable.

I have had the advantage of discussing in some detail the extensive investigation of the ground water conditions in Florida to which Mr. Malcolm Pirnie refers. It will be noted that the percolation is between 10 and 11 in., both in the chalk area of England and in the fossil limestone area of 2,670 sq. mi. in Florida, and the average annual rainfall in England was 27 in. as against 52 in. in Florida.

When Mr. Pirnie's comparative table is studied, it will be seen that whether a 6 wet-month or a 6 dry-month period is considered, the loss is about 17 to 18 in., whereas the loss by the English record is only 5 in. in the wet months and in the dry months about 10 in.; the explanation may be that, owing to its more southerly latitude and the maintenance of a more equable climate due to being girt by the sea, vegetation is more profuse and takes a higher toll of the rainfall.

Mr. Pirnie was fortunate in having so large and clearly defined an area on which to work, and in having been able to hit a drought period when the underground storage was heavily depleted and once again restored to its pre-drought condition.

I regret I am not able to furnish a table such as Mr. Pirnie gives to show the incidence of rain sorms at the percolation gauge. I did, however, plot year by year the rainfall and percolation for the wet and dry periods over the years 1876–1916, and from this it emerged that, on the average, some 9 in. of rain had to be recorded for the six summer months before there was any appreciable percolation: for the winter period the corresponding "handicap" was about 5 in. The summer period of 1881 actually had a rainfall of 11.00 in. with a percolation of 0.02 in., and in the winter period 1903–1904 a rainfall of 18.00 in. gave a percolation of 16.87 in. The plotted points scatter somewhat widely and for a period rainfall of about 14 in., summer percolations ranging from almost nothing to 4 in. are recorded, and winter percolations from 5 to 11 in.

In all these matters, the neglect of the carry-over effect may lead to difficulties in estimation: it may be that the most of the rainfall of a par-

ticular month occurs towards the end of that month, so that the resulting percolation only becomes effective in the following month. For example, in November, 1881, the rainfall and percolation were 3.62 and 2.48 in., respectively, whilst in December, the corresponding figures were 2.87 and 3.07 in.; for January, 1891, the figures were 2.10 and 2.16, whilst February gave 0.06 and 0.69 in.

Mr. Kennison's remarks about regional water developments indicate that wherever there is community of interest and concentration of population the water needs are most economically met by joint action. During my visit to Boston and by the courtesy of Mr. Winsor, I was able to inspect the Swift River project and learn about the working of the Boston Metropolitan District Water Supply Commission.

In England we have the London Metropolitan Water Board which supplies in detail the needs of a population of nearly 8 million people, and, in addition, affords bulk supplies to neighbouring undertakings, and which took over the eight water companies which until 1902 shared in the work of supplying the Metropolis. In other parts of the country there are Water Boards whose activities are limited to the construction and maintenance of head works and trunk aqueducts by which supplies are delivered in bulk to the constituent authorities who are responsible for distribution within their respective areas.

Apart from the formation of Boards, it has become usual to authorize the various authorities, through whose area a long trunk aqueduct may pass, to reserve a bulk supply from the aqueduct upon terms which are defined in the Act which authorizes the construction of the aqueduct: there is generally a time limit beyond which reservations cannot be made and the terms include a provision that a certain percentage of the quantity reserved shall be taken or paid for as if taken.

The method of determination of the actual charge for the water is explicitly set out: it varies a good deal according to local circumstances, for in some cases the major component may be capital charges, *e.g.*, a gravitation supply involving no treatment, whilst in others pumping and purification charges may be relatively large.

It was rather because I anticipated that I might have the opportunity of seeing the Main Dam and Dike of the Quabbin Reservoir that I gave a brief description of the Silent Valley cut-off work. There is a general similarity in the geological conditions at the two localities; in both, the material encountered was of varying character, though, as Mr. Kennison remarks, the fine material in the Silent Valley was much finer and less willing to part with its water than the fines on the Swift River project.

I find there is nothing so liable to lead to misconception as an attempt to compare costs, even for work carried out to the same general design, when labor conditions — hours of labor, wages, etc. — and costs of materials differ as much as they do between America and England, and the difficulty is accentuated when the designs differ as radically as in the present

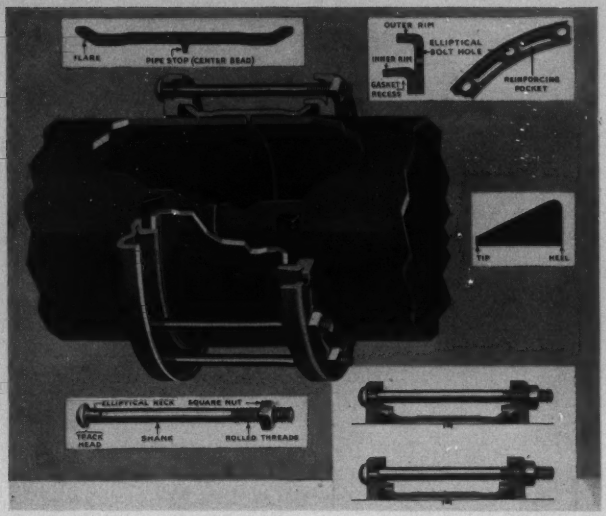
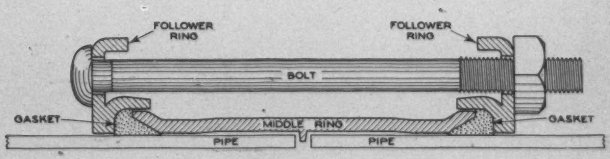
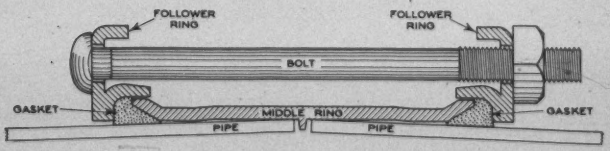


FIG. 1.— CUTAWAY VIEW, SHOWING CONSTRUCTION OF COUPLING.



PIPE IN STRAIGHT POSITION



PIPE IN DEFLECTED POSITION

FIG. 2.— HOW COUPLING PERMITS DEFLECTION OF PIPE.

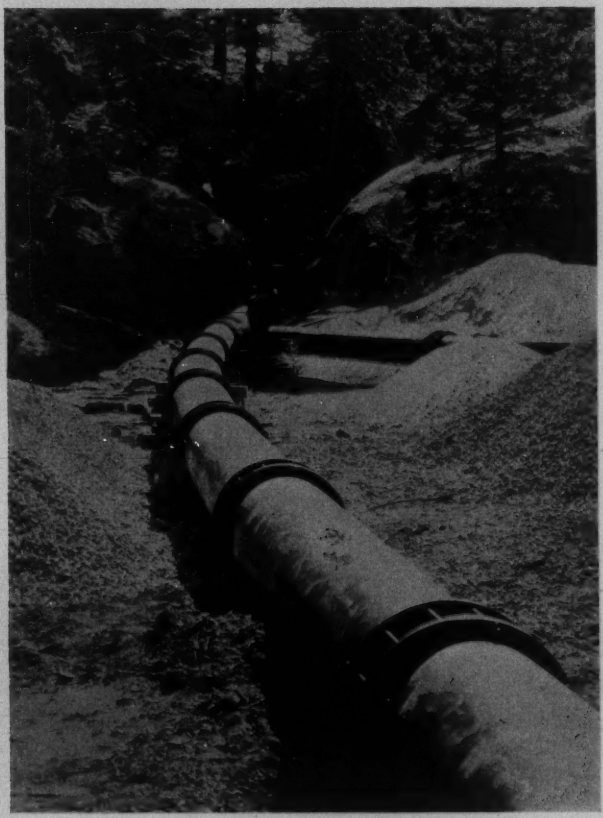


FIG. 3.— STANDARD COUPLINGS AND STRAIGHT LENGTHS OF PIPE WERE USED TO MAKE THIS CURVE.
Pikes Peak Line carrying water supply for Colorado Springs, Col.
Maximum working pressure 100 lb. per sq. in.

metal used. Figure 5 illustrates this point. The coupling shown was designed for a test pressure of 1480 lb. per sq. in., but it remained absolutely tight when tested to 1600 lb. per sq. in., a pressure sufficient to stress the pipe well beyond its yield point. Pressure values are derived by using Barlow's formula applied to the coupling middle ring.

With the middle ring as a controlling factor, the followers are designed to provide a corresponding adequate packing pressure, and the gaskets and bolts are proportioned in such manner as to produce a carefully engineered joint with a high ratio of strength to weight. Rigid specifications control and maintain the physical and chemical properties of all raw materials used. The middle rings are of high-grade open hearth steel, rolled to a special-section which is then cut into the proper lengths, cold-rolled into shape and shop-welded by the resistance or flash-welding process. Small sizes are made from seamless tubing cut into proper lengths. Follower rings are hot-pressed and cold-formed from steel plate by a series of hydraulic-press operations; large sizes are cut from special-section bar steel and then formed into circles and welded like middle rings. Each welded middle ring and follower ring is first made undersize and then stretched to proper size to insure uniformity and to test the weld.

The bolts used with these Couplings have a higher tensile strength than ordinary bolt steel. Rolled threads insure the same yield and ultimate strength in the threaded section of the bolt as in the shank. Although black-steel bolts are standard, they may be Cadmium-plated or otherwise coated with either a metallic-coating or other specified coating material. Where the coupling is to be field-coated with a thick bituminous material the bolts are shop-coated with the proper primer.

Permanent Tightness of Coupling. On the subject of joint-tightness, test records on completed water lines using these flexible couplings show in practically every case that every joint in the line is absolutely tight; meaning that they do not show a sweat. Joint-tightness is experienced with these flexible couplings under severe or unusual conditions of pipe line installation and operation, as well as under ordinary pipe-laying condition . There are cases where the pipe line is subjected to extreme vibration. This is true of the coupled 24-in. main supply line at Utica, N. Y., where the line crosses over a deep ravine on a very light suspension bridge; and at Philadelphia where the coupled 36-and 48-in. steel water mains are adjacent to the subway structure. No leakage occurred on the initial test of these water lines, and it has since been reported that the joints are continuing to function without any sign of leakage whatsoever. In the laying of a 36-in. coupled water line at Detroit, the trench bottom was so soft in some places that the workmen joining the pipe sank up to their knees and were pulled out of the mud by ropes, but the test on the completed pipe line showed no leakage.

It is the customary procedure on the part of those familiar with these couplings, to have the backfilling of the trench proceed behind the pipe-

joining operation, thus leaving the leakage test until after the line has been completed.

Simplicity of Coupling. The human equation in the making of field joints is practically eliminated by the simplicity of the coupling. Plain-end pipe is used and the field work consists merely of assembling and bolting together a number of rings which are standard factory-made parts. All parts of the coupling are on the outside of the pipe, giving a smooth interior of uniform diameter at the joint, with no inside projections to interfere with the carrying capacity of the pipe line. The coupling also permits machine-spun linings to be uniformly applied all the way to the ends of the pipe.

How the Coupling is Installed. To assemble this coupling, a follower ring and a gasket are slipped over each plain-end pipe section. The gasket and follower ring are positioned at a convenient distance (about 6 or 8 in.) from the end of the pipe. The flared-end middle ring is then shoved over the end of the laid section of pipe until the pipe-stop or center-bead inside the middle ring comes up against the pipe-end. The other pipe-end is then stabbed into the middle ring until it also reaches the pipe stop. The next operation is to slide the gaskets in place against and under the middle ring flares after which the follower rings are moved up against the gaskets and revolved until the bolt holes line up. The bolts are next inserted through the follower rings and the nuts are run up by hand and finally tightened with a ratchet wrench. To insure uniform compression of the gaskets, diametrically opposite bolts are drawn up at the same time by two men working on opposite sides of the coupling. All bolts are track-head, having an elliptical neck under the head which fits into the elliptical holes of the follower rings, thus preventing the bolts from turning while the nuts are being tightened. Where no substructures interfere and where the size and weight of the pipe will permit, installation can be further simplified and quickened with these flexible couplings by joining the line above the ditch and then lowering it. No harmful stresses are set up in the joint or in the pipe metal during the lowering, owing to the dual flexibility of the joint.

Installation Time. Time studies made on installations of various sizes of coupled pipe, show that the assembling time from the placing of the first coupling part on the pipe to the final tightening of the bolts, may, under ordinary conditions be estimated on the basis of two man-minutes per bolt. For example, a 12-in. coupling has eight bolts requiring a total of sixteen man-minutes or the equivalent of two men working eight minutes to join the pipe with the couplings. Allowing 50 cents per man-hour, the labor cost per joint would be 13½ cents for the 12-in. size. A 48-in. coupling having 28 bolts would require a total of 56 man-minutes or the equivalent of two men working 28 minutes to complete the joint. The labor cost in this case would be 47 cents at 50 cents per hour per man. The estimated time allowance of two man-minutes per bolt to connect the pipe with the coupling, checks out quite closely in all sizes under the usual pipe-laying conditions. It includes all assembly operations of connecting the

pipe and handling the coupling parts after delivery alongside of the trench.

Adaptability of Coupling for Various Uses. In addition to its primary purpose of joining pipe on new lines, there are other uses to which the sleeve-type coupling is adaptable, due to the ease and speed with which it s assembled or dismantled. These couplings are used extensively in pairs

FIG. 6.— REMOVABLE LENGTH OF COUPLED PIPE, PERMITTING INSERTION OF "GO-DEVIL" FOR MAIN-CLEANING PURPOSES.

for main-cleaning purposes. In this work, as shown in Fig. 6, a short section of pipe is first connected into the line at each end with couplings. Subsequently, whenever it is desired to insert a "go-devil" for recleaning the main the couplings are simply dismantled. In a similar manner, pairs of couplings are used for cutting-in valves and fittings, or for quickly inserting a new length of pipe in the line to replace a broken or defective section of pipe. (Fig. 7.) They are also used on water and sewage pumps to take up vibration and to permit easy disconnection of the pipe from the pump, for

FIG. 7.— VIEW OF COUPLINGS EACH SIDE OF A VALVE.
Showing how pairs of couplings are used for cutting in valves and for preventing strain at the valve connections.

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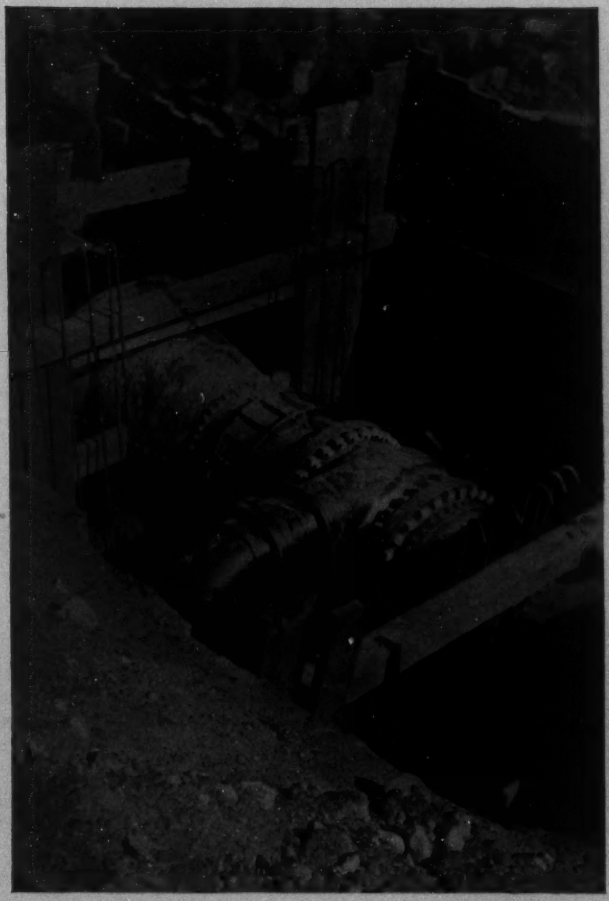

FIG. 7.— VIEW OF COUPLINGS EACH SIDE OF A VALVE.
Showing how pairs of couplings are used for cutting in valves and for preventing strain at the valve connections.

any reason. Their use facilitates as well the installation of pipe in cramped working quarters, in pipe galleries, tunnels, water-filtration plants and sewage-treatment plants.

For these various purposes the middle ring of the coupling is furnished without the usual inside pipe-stop or "center-bead" in order that this ring may slide completely over the end of the pipe or move backward or forward as required to make the joint or dismantle it.

FIG. 8.— A 93-IN. COUPLING CONTRASTED WITH A 3/8-IN. SIZE (on Hood of Car).

Range of Sizes. A wide range of coupling sizes is made for both plain-end steel and cast-iron pipe. Steel couplings are made for steel pipe in sizes from 3/8 up to 96 in. For cast-iron plain-end pipe, the range of steel coupling sizes is from 2 to 72 in. and the range of cast coupling sizes from 2 to 30 in. inclusive. (Fig. 8.)

Installations. Several views of field installations of water lines are included in this paper. They are representative of various sizes and types of water-pipe installations with these couplings. See Figures 9–13.

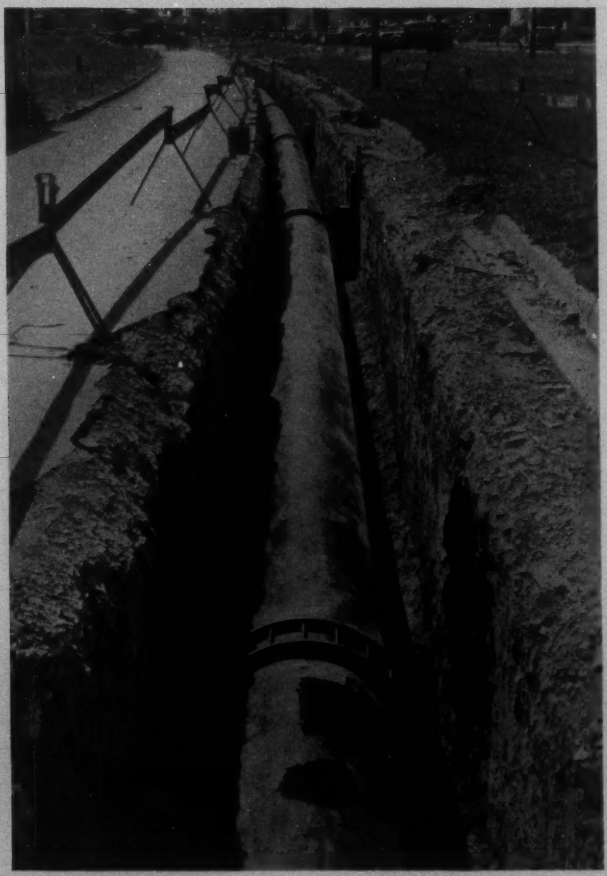

FIG. 9.— A 30-IN. STEEL WATER MAIN AT CLEVELAND, OHIO.
Showing curvature in the line made with straight pipe and standard couplings. Note narrow trench.

FIG. 10.—A 36-IN. STEEL EQUALIZING MAIN AT BUFFALO, N. Y.
Showing straight-line accuracy of laying the coupled pipe with a green crew of unskilled labor.

FIG 11.— A VIEW OF THE 13-MILE 60-IN. WATER CONDUIT OF COUPLED STEEL PIPE RECENTLY COMPLETED AT ST. LOUIS, MO.

FIG. 12.— INSTALLATION OF A 48-IN. COUPLED STEEL WATER MAIN THROUGH A RESIDENTIAL SECTION OF WASHINGTON, D. C.
The residents were relieved to find that the joining of the steel pipe sections was a noiseless job.

FIG. 13.— A 42-IN. COUPLED STEEL WATER TRANSMISSION LINE AT FORT WAYNE, IND.
Showing a portion of the line crossing a fill and then making a curvature.

LININGS FOR CAST-IRON PIPE.

BY THOMAS F. WOLFE.*

[*Read September 25, 1936.*]

A logical starting point for a paper dealing with linings for cast-iron pipe is consideration of the condition that indicates the need for a lining. This condition is tuberculation of the pipe resulting in reduced carrying capacity. Tuberculation can be defined briefly as a formation of nodules on the interior of the pipe. These nodules increase the frictional resistance to the flow of water and cut down the area of the waterway. Without going into details regarding the characteristics of water that cause this trouble, it can safely be said that any water that is undersaturated with calcium carbonate will cause tuberculation. Conversely, tuberculation would not be expected in saturated waters. Another characteristic that can be relied upon as a tuberculation index is the pH (a measure of the acidity) of the water. Waters having a low pH, that is from about seven down, ordinarily cause tuberculation, although not always. As examples of exceptions, a water with a pH of 6.8 and a calcium alkalinity of 350 p.p.m. would be non-tuberculating while a water with a pH of 8 and a calcium alkalinity of 25 p.p.m. would cause tuberculation. In general, however, the pH of the water is a fair indication of its tuberculating qualities. A curve of the approximate pH and calcium alkalinity necessary for calcium carbonate saturation as prepared by Mr. John R. Baylis (Fig. 1) is an excellent guide to the relationship between these factors and tuberculation. Waters that have characteristics that place them above this curve would not cause tuberculation while those that fall below the curve would.

While the fact, that under certain conditions, pipe lines suffer a loss in carrying capacity, has been recognized for a number of years, it was not until a greater knowledge of chemistry of water was acquired that the actual causes of this loss of carrying capacity were determined. As the art of water treatment improved, remedies that could be applied to the waters themselves were developed. With our present knowledge of the art, we know that if the reduced carrying capacity is caused by chemical characteristics of the water, three courses are available for the correction of the trouble: First, treatment of the water; second, lining of the pipe that is to carry the water; third, a combination of water treatment and pipe lining. Reduced carrying capacity caused by influences other than the quality of water will be dealt with later in this paper.

Before the characteristics of any water, so far as tuberculation is concerned, can be predicted, the pH should be determined and a chemical analysis made. A map (Fig. 2) of the United States shows the areas where

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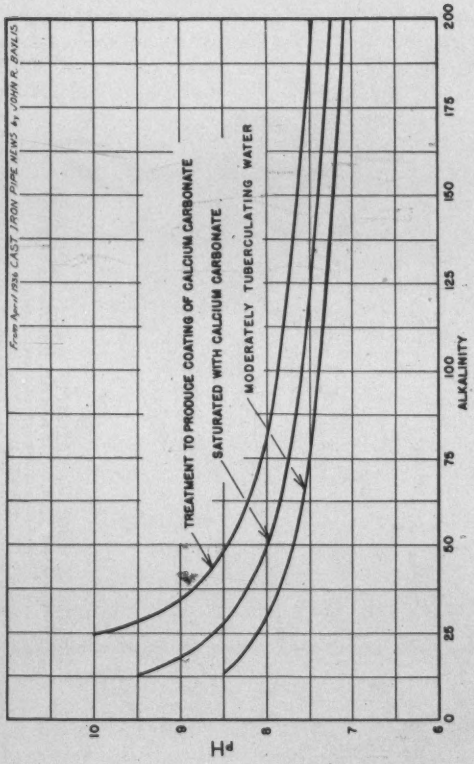
From April 1936 CAST IRON PIPE NEWS by JOHN R. BAYLIS
TREATMENT TO PRODUCE COATING OF CALCIUM CARBONATE
SATURATED WITH CALCIUM CARBONATE
MODERATELY TUBERCULATING WATER
pH
10
9
8
7
6
0
25
50
75
100
125
150
175
200
ALKALINITY

FIG. 1.

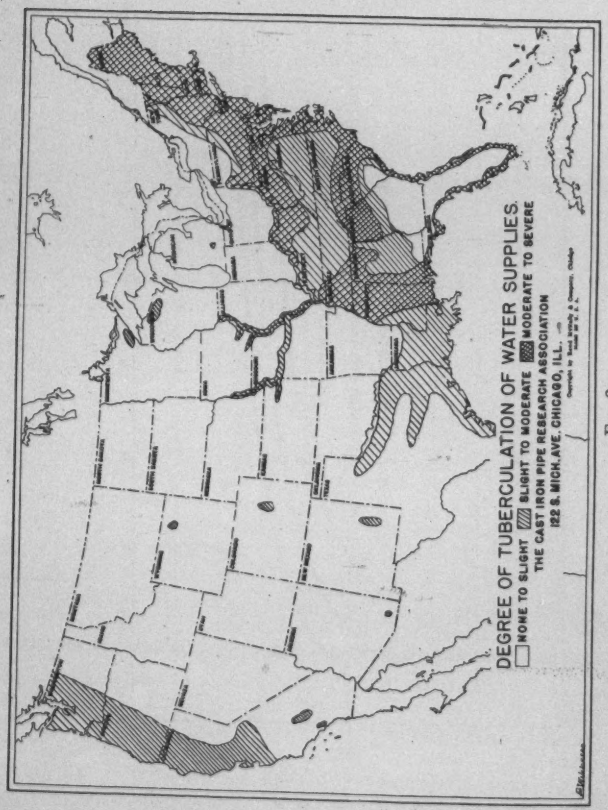
DEGREE OF TUBERCULATION OF WATER SUPPLIES.
NONE TO SLIGHT
SLIGHT TO MODERATE
MODERATE TO SEVERE
THE CAST IRON PIPE RESEARCH ASSOCIATION
122 S. MICH. AVE. CHICAGO, ILL.

FIG. 2.

tuberculation of various intensities is to be expected. This map is based on the following information: pH of water as furnished to consumers; actual experience with tuberculation based on replies to a questionnaire sent out by Committee A-21 of the American Standards Association; cases of low friction factor included in the report of the Committee on "Friction Coefficients" of THE NEW ENGLAND WATER WORKS ASSOCIATION; low friction factors reported in various engineering papers and sales of lined cast-iron pipe. With this information it was possible to indicate areas where tuberculation of the following degrees is to be expected; none to slight; slight to

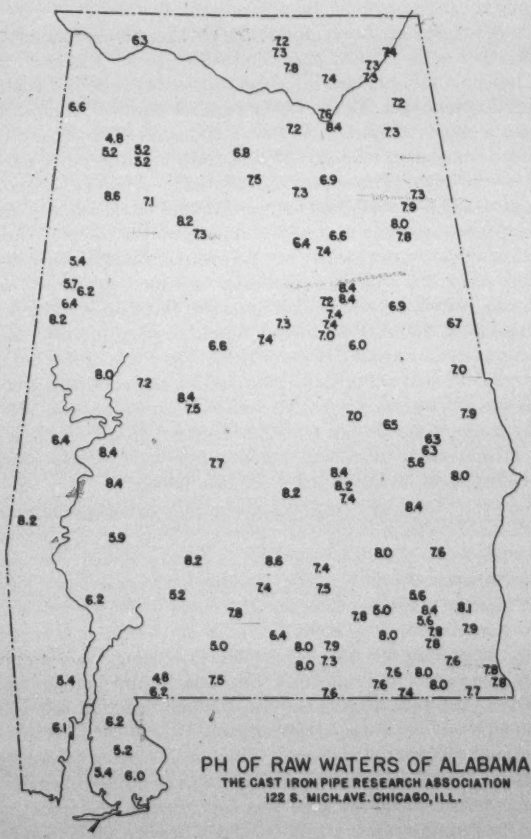

FIG. 3.

moderate; moderate to severe. The resulting map must be considered as an approximation since it is a fact that in some parts of the country waters only a few miles apart are widely different in chemical characteristics. This is shown by the detailed map of Alabama (Fig. 3) which gives the pH values of the public water supplies in that state. It is to be noted that a water with a pH of 5.0 is found only a short distance away from one having a pH of 8.4. In other sections of the country, such as Indiana, the lowest pH reported is 7.0 and the highest pH is 8.0. The map (Fig. 2) is useful only as an indication of where tuberculation might be expected as well as an index of the severity of the tuberculation problem throughout the country.

The treatment of water for the purpose of eliminating tuberculation has been dealt with in many papers presented before this and other water works bodies, and it is not my intention further to consider this phase of the tuberculation problem. It can safely be said, however, that with modern treatment methods, a finished water can be furnished that has all the qualities that a consumer could ask for and that has little or no effect on the interior of the pipe. The adjustment of water to reduce tuberculation to zero requires a delicate balance, and care should be exercised so that a thin film of calcium carbonate is deposited on the wall of the pipe and then the pH maintained at a point where the film neither builds up nor dissolves.

While recognizing the fact that water treatment provides a remedy for low carrying capacities, we must also consider those cases where raw waters must be handled. In this class are well supplies, spring supplies, and supplies from uninhabited or protected water sheds. As these types of water often receive no treatment other than chlorination, the elimination of tuberculation is not a by-product of other treatment processes already provided for the purpose of furnishing a potable finished water. In those cases, as well as in the case of pipe lines bringing raw water to treatment plants, tuberculation must be taken care of by pipe linings.

When cast-iron pipe was first used for conveying water, no coating or lining was used. The pipe was laid in the ground in just the same condition as that when it came from the moulds. It became evident after some years of use that the interior of the pipe was affected by the water, and as early as 100 years ago a recommendation was made to the French Academy of Sciences that the difficulty could be cured by the use of a cement lining. Not long after this the use of bituminuos coatings was proposed, and probably because of the simplicity with which they were applied as well as their low cost they soon came into common use. In this country, all cast-iron pipe sold for water works purposes after about 1858 was provided with a dipped bituminous coating. This dipped coating served its purpose for a time, even in those waters that we now know cause tuberculation.

Cement as a lining for pipe was first used in this country in New England for lining service pipes. Unlined service pipes being small in diameter soon became clogged with rust, and the need of some form of

protection was felt at an early date. The mains themselves being larger in diameter were undoubtedly tuberculated, but the effect was not felt as soon as was the case with smaller service pipes. The next step in the development of lined pipe was the production of a pipe that consisted of a thin wrought-iron shell having a cement lining and cement coating. This pipe came into use about ninety years ago and was installed to considerable extent in New England, New York and Pennsylvania until about 1915. With this type of pipe it was difficult to make a good joint or to tap the pipe. Furthermore, because of the structural weakness of the pipe, the outer coating spalled off with the result that the shell corroded and the pipe failed. These pipes were in use long enough to demonstrate the fact that there was comparatively little deterioration of the cement linings. A flow test made on one of these lines that had been in service for over 40 years in a very active water gave a value of "C" in the Williams and Hazen formula of 104. Considering the fact that natural cement was used and a rougher lining resulted, it is highly probable that the original coefficient did not greatly exceed this figure. Cement-lined service pipes are still used in New England and an examination of some of these that have been in service for many years indicates that even where there is no water treatment the deterioration of the lining is very slow.

The development of cement linings for cast-iron pipe received its first impetus through J. E. Gibson of Charleston, S. C. In Mr. Gibson's experience he had become familiar with cement-lined and cement-coated water pipe and he felt that a cement lining applied to cast-iron pipe would solve the tuberculation problem. In coöperation with one of the pipe producers, cast-iron pipe was first lined by the "projectile" process. In this process the pipe is placed in a vertical position, a "projectile" having a diameter equal to the finished diameter of the lined pipe is inserted in the bottom of the pipe. On top of the "projectile" is placed a sufficient amount of mortar to line one pipe. The "projectile" is then drawn through the pipe, spreading the mortar along the wall. While this method of lining was slow and laborious it furnished a fairly good lining. It soon became evident that this method was not adapted to mass production, and the centrifugal process was developed. This process consists in distributing the necessary quantity of cement mixture, by means of a long trough, evenly throughout the length of the pipe. The trough is usually constructed of circular cross-section and is so placed that after dumping the material the trough acts as a trowel to assist in the even distribution of the mixture during the early period of spinning. After this the trough is removed and the rate of spinning increased. After spinning at low speed, for a minute or two, the machine is stopped and any imperfections in the lining are corrected. Then the spinning is continued at a higher rate of speed for a short period. The vibration of the pipe while revolving, combined with the centrifugal force, produces a dense lining that adheres to the wall of the pipe. The lining created by this method is free from imperfections, the surface is very smooth to the touch

and offers very little frictional resistance to the flow of water. The excess mortar is removed from the bell, and the pipe is placed in the curing yards. While the cement is setting, the ends of the pipe are covered with temporary caps of canvas or burlap to prevent too rapid loss of moisture from the lining. In general, the curing of the lining should follow accepted methods of curing concrete.

The fittings are lined by hand. Small fittings have the lining applied by means of a brush in layers as the cement sets up until the required thickness is reached. In larger fittings the mortar is applied with a trowel.

Cement and other types of lining materials and methods are the object of continual study by pipe producers and present-day linings not only are smoother but also less soluble than linings used in the past. Consequently they will have a longer life and less tendency to affect the quality of the water carried.

As the Charleston installation was the first one to use cement-lined cast-iron pipe in this country, great interest was shown in what was accomplished by the use of the lining. Mr. Gibson has made many tests for the purpose of determining the friction factor. After a few years it became evident that the lined pipe was maintaining its original carrying capacity. Tests on a 16-in. line installed in 1922 gave the following values of "C":

Date Tested	Williams-Hazen "C"
1922	135
1923	128
1930	145
1933	139
	137 average

This 16-in. line was lined with natural cement using the "projectile" method. Centrifugally-lined pipe has a smoother surface, and it is to be expected that a higher initial coefficient will be obtained and that it will be maintained at least as well as is indicated in the line tested. As an example of the smoothness of centrifugally-lined pipe, a test made at the University of Illinois gave the following friction factors:

Size	Williams-Hazen "C" for Actual Diameter
4	149
6	150
8	152

These and other tests have indicated that for design purposes, a value of "C" of 140, based on nominal diameters, can safely be assumed.

The present tentative specifications for cement lining for cast-iron pipe as prepared by Committee A-21 of the American Standards Association provides for the following thicknesses of lining:

Size of Pipe Inches	Minimum Thickness of Cement-Mortar Lining Inches	Size of Pipe Inches	Minimum Thickness of Cement-Mortar Lining Inches
4	1/8	14	3/16
6	1/8	16	3/16
8	1/8	18	3/16
10	1/8	20	3/16
12	1/8	24	3/16

In order to give a rough approximation of the saving in pumping cost that can be expected when lined pipe is used and water that causes severe tuberculation is handled, the following schedule is presented:

Cost of Pumping 7 m.g.d. Through One Mile of 24-in. Main — Friction Head Only.

Motor Efficiency 90 per cent. Pump Efficiency 85 per cent.

Standard Cast Iron Pipe.	*Cement Lined Pipe.*
C = 130 New Pipe.	C = 140 Indefinitely.
C = 75 After 50 Years.	
C = 97 Average for 50 Years.*	

*Actual average based on Williams and Hazen age relationship.

Cost of Power.

	Unlined Pipe.			Lined Pipe.				
Per K.W.H.	First Year.	50th Year.	Annual Average 50-Year Period.	First Year.	50th Year.	Average Annual Saving 50-Year Period.	Extra Cost of Cement Lining.†	Annual Return on Lining Cost.
1.0c.	$ 898.12	$2 539.15	$1 552.32	$ 781.70	$ 781.70	$ 770.62	$1 850.00	42.0%
1.5c.	1 347.18	3 808.72	2 328.48	1 172.55	1 172.55	1 155.93	1 850.00	62.5%
2.0c.	1 796.24	5 078.30	3 104.64	1 563.40	1 563.40	1 541.24	1 850.00	83.5%
Cost of Pumping 1.8 m.g.d. Through One Mile of 12-in. Main — Friction Head Only.								
	C = Same as Above.			C = Same as Above.				
1.0c.	544.58	1 511.14	955.15	474.72	474.72	480.43	900.00	53.5%
1.5c.	816.87	2 266.70	1 432.73	712.08	712.65	720.65	900.00	80.0%
2.0c.	1 089.16	3 022.28	1 910.30	949.44	949.44	960.86	900.00	107.0%

†Based on current costs of linings.

In the preparation of this schedule, only two sizes of pipe have been considered, each working at one rate of flow. In general, it can safely be stated that based on the average pumping cost over a 50-year period the lining pays for itself within a few years regardless of diameter if a tuberculating water is handled.

The alternative to providing linings to reduce pumping costs is to treat the water so that tuberculation will not result. In doing this work, two courses are open to the waterworks operator: (1) merely to treat the water to prevent tuberculation of mains and to disregard the additional soap that will be used by the consumer; (2) to so treat the water that internal corrosion is prevented without increasing soap consumption. If the first method is used, the additional cost of lime at present market prices to treat a water requiring 47 lb. of lime per million gallon will be in the neighborhood of

27c. per million gallons and the resulting increase in hardness about 10 p.p.m. In this case the annual cost of lime for a 24-in. pipe, delivering 7 m.g.d. would be $689.85 and for a 12-in. pipe delivering 1.8 m.g.d., $177.39. The total cost to the consumer, however, would exceed this amount due to the necessity of using greater amounts of soap. Baylis has stated that the over-all cost of treating water including soap costs is 1c. per capita per year for each p.p.m. of hardness added. On this basis, assuming a per capita consumption of 150 g.p.d. the total annual cost of treatment to prevent tuberculation in the case of the 24-in. pipe would be $4 667 and in the case of the 12-in. pipe $1 200. By using soda ash in place of lime, the over-all cost for treatment would be about the same. In the case of lime treatment, however, the cost is split between the water department for lime and the consumer for soap. In the case of soda ash treatment, the entire cost would be borne by the Water Department. The advantage of treatment of water over lining the pipe is the fact that where linings only are provided, corrosion of house piping continues and the cost of replacing piping within buildings is borne by the consumer.

It is to be remembered that in the examination of old lines, the finding of low carrying capacity does not necessarily indicate tuberculation. Losses of carrying capacity may be due to a number of other causes, among them: (1) reduction of area due to the deposition of silt; (2) choking of pipe due to debris that entered the line during construction; (3) partly closed valves; (4) accumulation of air at summits; (5) inclusion of a number of fittings in the line; (6) inferior pipe, e.g., the 9-ft. lengths of pipe used many years ago that not only had more joints but rougher interiors. All of these difficulties can be taken care of by properly designed and properly operated pipe lines, and the waterworks man is warned against arriving at conclusions that all low carrying capacity is due to tuberculation.

In conclusion I believe that several points should be brought out: (1) Where treated water is handled through pipe lines it is possible to so treat the water that tuberculation is no longer a problem; (2) the areas where either severe or mild tuberculation are to be expected, cover only about 25 per cent. of the country; (3) where tuberculating waters must be handled, cement and other linings are available that give pipe coefficients upward of 140; (4) the reduced cost of pumping that results where lined pipe is used and tuberculating water handled will usually amortize the cost of the lining within a few years; (5) the use of linings where tuberculating waters must be handled not only results in lower pumping costs but in some cases in lower capital charges due to the use of smaller-diameter pipe; (6) experience has shown that even with untreated waters, the life of the lining approaches 100 years and where treated waters are handled, the lining should last indefinitely.

PROCEEDINGS.

FIFTY-FIFTH ANNUAL CONVENTION.

NEW YORK, N. Y.

September 22 to 25, 1936.

The following is a synopsis of such parts of the proceedings of the Fifty-fifth Annual Convention as appear to be of value for the record.

The Fifty-Fifth Annual Convention of the NEW ENGLAND WATER WORKS ASSOCIATION was held at the Hotel Pennsylvania, New York, N. Y., September 22 to 25, 1936.

TUESDAY, SEPTEMBER 22.

Morning Session.

The Convention was called to order by President Roger W. Esty at 11 A.M.

ADMINISTRATIVE REPORTS.

The Annual Reports of the Secretary, Treasurer and Finance Committee were presented (see p. 436), accepted and placed on file.

CLOSING OF POLLS AND APPOINTMENT OF TELLERS.

THE PRESIDENT declared the polls closed and appointed three tellers: Charles J. Crump, Massachusetts; Joseph E. Moore, Vermont; and Maurice A. Libby, Maine.

Luncheon Session.

The welcome of his Honor, Mayor La Guardia, was extended to the Association by Mr. Joseph Goodman, Chief Engineer, Department of Water Supply, Gas and Electricity, New York, N. Y.

PRESENTATION OF CERTIFICATE OF HONORARY MEMBERSHIP TO THADDEUS MERRIMAN.

FRANK E. WINSOR. Mr. Goodman, representing his Honor the Mayor, Mr. President, Members of the NEW ENGLAND WATER WORKS ASSOCIATION, and guests: It is a great pleasure and a great honor to have been selected by your president to make this presentation of honorary membership to one who for many years was an associate and a warm personal friend.

It is a great regret to me, as it is to you, that Mr. Merriman could not be here in person, but he has happily designated to receive this membership for him one who for a long time has been closely associated with him.

Thaddeus Merriman was born in New Haven, Connecticut, a son of Mansfield Merriman, also a native of Connecticut, eminent teacher and engineer, who had the happy faculty of expressing in written words the mathematics of engineering that they might be understood by some of us who are less gifted, and who is known among the engineers who for more than two generations have used his textbooks and regard them with the highest esteem.

Thaddeus started his early career in New Haven, but very early in life the star of Bethlehem led him to Pennsylvania, where he graduated from Lehigh in 1897. Following his graduation he spent three years in the tropics, on surveys and studies of the then projected canal through Nicaragua. He entered the employ of the East Jersey Water Company in 1900 and very soon thereafter came under the influence of that master mind, J. Waldo Smith, who, as you know, was a past president and honorary member of this Association. His work for the East Jersey Water Company included the design of a rapid sand filtration plant, the first large plant of this kind ever built, and the construction of a large dam.

In 1905 he again became associated with J. Waldo Smith on the Catskill Water Supply for the City of New York. On this work he advanced from assistant to the chief engineer to deputy chief engineer, and in 1922, upon the resignation of Mr. Smith as chief engineer, Mr. Merriman became chief engineer of this great work. In this capacity as chief engineer he completed the tunnel in connection with the Gilboa dam and reservoir, and the new city tunnel was, in the main, completed during his term of office, this being a tunnel eighteen miles long, extending from Westchester County, Yonkers, to the boroughs of Queens and Brooklyn—a tunnel some 17 feet in diameter, to supply water to these various districts, and costing in the vicinity of $45,000,000.

In addition to this work he also laid out the next addition to the New York City supply, the Delaware River project. In connection herewith he distinguished himself as an engineer—I might almost say as a lawyer, although, so far as I know, he never attempted to practice—in the interstate litigation before the United States Supreme Court, which Court decided that the City of New York had the right to go to the Delaware River for its water supply.

Mr. Merriman presented a paper to this Association five years ago at its annual convention, which paper was awarded the Dexter Brackett Memorial Medal. The title of this paper was "The Law of Interstate Waters."

Mr. Merriman resigned as chief engineer of the Board of Water Supply in November, 1933, in order to take up consulting practice. Among other engagements his consulting practice has included that of chairman of the Engineering Board of Review of the Metropolitan Water District of Southern California, this district being engaged in bringing water from the Colorado River over the mountains and across the desert into the Metro-

politan District of Los Angeles. He has been chairman of the Board of Water Department upon the construction of the Fort Peck dam and reservoir in Montana, and also consulting engineer for the Board of Water Supply of the City of New York. He is well known as an author, being editor in chief of the American Civil Engineers' Handbook, and a frequent contributor to engineering literature. He has done remarkably efficient work in studies of Portland cement and concrete, with the results of which many of you are familiar.

In 1900 Lehigh University conferred upon him the honorary degree of Doctor of Engineering.

In accepting this honorary membership, Mr. Spear not only honors Mr. Merriman but honors himself. It is a great pleasure to me to present to you, Mr. Walter E. Spear, long a member of this Association, who succeeded Mr. Merriman as Chief Engineer of the Board of Water Supply of New York City, this certificate of honorary membership. [Applause.]

WALTER E. SPEAR. Mr. Winsor, Mr. President: I am authorized by Mr. Merriman to express his sincere gratitude at this high honor which you have done him, and he further wishes me to express his deep regret that he could not be here to receive this certificate in person. [Applause.]

AWARD OF DEXTER BRACKETT MEMORIAL MEDAL.

KARL R. KENNISON. Mr. President, members and guests of the Association: Your committee includes also Mr. King of Taunton and Mr. Saville of Hartford. We had a great number and a great variety of papers from which to select the recipient of this medal, and we had no easy task in making the selection. However, we were unanimous in the opinion that the recommendation should be for the paper on "Providence Water Treatment," by Mr. Elwood L. Bean of Providence, Chemist of the Scituate Reservoir Division, Department of Public Works of that city.

Mr. Bean, as his title implies, is a chemist. He received his training in that line in special work at Brown University, but more particularly in the practical experience which he obtained in four years of work with the State Board of Health in Augusta, Maine, Department of Sanitary Engineering, from which he came directly to the city of Providence just at the time when the filtration plant from the new Scituate reservoir was being put into operation. He has been there ever since, i.e. for the last ten years. He has been very resourceful in meeting the variety of problems encountered in that filtration plant, among them notably the trouble which developed with manganese and which made it necessary completely to revise the method of treating the water. He has also had a great deal to do with the problems of corrosion, and those of you who have read his paper are familiar with his work along that line. He has certainly been a very resourceful employee of the city in taking care of their problems.

It gives me great pleasure as chairman of the committee to present Mr. Bean the Dexter Brackett Memorial Medal of the Association. This

medal is in memory of Dexter Brackett, who was Chief Engineer of the Boston Metropolitan Supply in the early days.

I take great pleasure, Mr. Bean, in presenting you with this medal. [Applause.]

ELWOOD L. BEAN. Mr. President, Mr. Kennison: Looking over the list of recipients of this medal for the last twenty years, their work and the papers they have presented, I cannot but feel that my own was rather a minor contribution. There is a good deal of doubt in my mind that my contribution warranted any such award. However, I sincerely appreciate the honor and am very glad if the material presented has been found of value by the members of this Association. I thank you. [Applause.]

Afternoon Session.

A paper, "The Development of the Water Supply of the City of New York," was read by Joseph Goodman, Chief Engineer, Department of Water Supply, Gas, and Electricity, New York, N. Y. Fred B. Nelson, J. N. Brooks, E. Sherman Chase, and Linn H. Enslow participated in the discussion.

A paper, "Additional Water Supply for the City of New York," was read by Walter E. Spear, Chief Engineer, Board of Water Supply, New York, N. Y. Percy A. Shaw discussed the paper.

A paper, "The Development of the Ground Water Supply of the City of Dayton, Ohio," was read by Wallace W. Morehouse, Director, Department of Water, Dayton, Ohio. Harold L. Brigham, Henry T. Gidley, E. J. Cleary, E. Sherman Chase, Roger G. Oakman, Linn H. Enslow, Donald C. Calderwood, Elwood L. Bean, and Theodore L. Bristol took part in the discussion.

WEDNESDAY, SEPTEMBER 23.

Morning Session.

The following Committees presented reports:

Committee on the Sanitary Scoring of Water Supplies.
Committee on Education.
Legislative Committee.
Representative on A.S.A. Project B-36, Standardization of Dimensions and Material of Wrought Iron and Wrought Steel Pipe and Tubing.
Committee on Simplification of Manhole Frames and Covers.
Committee on Specifications for Cast-Iron Pipe.
Committee on Pipe Flanges and Fittings.

It was voted to continue all of these committees except the Committee on Manhole Frames and Covers.

Secretary Gifford announced the election by the Executive Committee of the following:

Members.

Christopher F. Bingham, Chemical Engineer, Columbia Alkali Corporation, New York, N. Y.
Frank Allen Chase, Civil Engineer, State Department of Public Works, Sharon, Mass.
Eugene A. Drumm, Chief Inspector, Bureau of Water Department of Water Supply, Gas and Electricity, New York, N. Y.
Thomas Aloysius LaCava, Sanitary Engineer, Chelsea Water Department, Chelsea, Mass.
W. W. Morehouse, Director, Department of Water, Dayton, Ohio.
Marshall Barker Palmer, Consulting Engineer, Water Division, Syracuse, N. Y. (reinstated).
Ralph L. Pollard, Water Commissioner, Sharon, Mass.
Leslie Sherman, Assistant Sanitary Engineer, Connecticut State Department of Health, Hartford Conn.
George Allen Stetson, Water Commissioner, Sharon Mass.

Associates.

Birch Manufacturing Company, manufacturers of pump valves and regulator relief valves, Chicago, Ill.
Darco Corporation, manufacturers of activated carbons, New York City.
W. & L. E. Gurley, Surveying Instruments, Troy, N. Y.
Homelite Corporation, manufacturers of portable pumps and generators, Port Chester, N. Y.
McWane Cast Iron Pipe Company, manufacturers of cast-iron pipe and special castings, Birmingham, Ala.
Reilly Tar & Chemical Corporation, manufacturers of coal tar products, Indianapolis, Ind.
L. A. Salomon & Bros., importers of minerals, clays and chemicals, New York, N. Y.

The balance of the morning session was given over to a "Symposium on the 1936 Floods in the Northeastern United States." This symposium was divided into two divisions: (1) Public Health Aspects; (2) Hydrology.

The Public Health Aspects were discussed in papers by Anselmo F. Dappert, Assistant Engineer, New York State Department of Health; W. L. Stevenson, Chief Engineer, Pennsylvania Department of Health; Arthur D. Weston, Chief Engineer, Massachusetts Department of Public Health; F. H. Waring, Chief Engineer, Ohio Department of Health—this paper being read by F. C. Dugan; and H. S. Hutton, Eastern Sales Manager, Wallace & Tiernan Company, Inc., Newark, N. J.

These papers were discussed by President Esty, Donald C. Calderwood, W. C. Hawley, and Warren J. Scott.

The Hydrology was covered in papers by Montrose W. Hayes, Chief, River and Flood Division, Weather Bureau, Washington, D. C.; Dr. Horace R. Byers, meteorologist, Division of Research, U. S. Weather Bureau, Washington, D. C.; and Caleb M. Saville, manager and chief engineer, Water Bureau, Metropolitan District Commission, Hartford, Connecticut.

THURSDAY, SEPTEMBER 24.

Morning Session.

The following committees presented reports:

Committee on Pipe Line Friction Coefficients.
Committee on Technical Subjects.
Committee on Water Main Disinfection.

These reports were accepted and placed on file.

A paper, "The Genesis of Floods," was read by Robert E. Horton, Consulting Hydraulic Engineer, Vorheesville, N. Y. Montrose W. Hayes and Caleb M. Saville discussed the paper.

A paper, "Operating Experiences with Anthra-Filt," was read by H. S. R. McCurdy, Chief Engineer, Philadelphia Suburban Water Company, Bryn Mawr, Pa. Elwood L. Bean, H. G. Turner, and George D. Norcom took part in the discussion.

A paper, "The Katadyn Process of Water Purification," prepared by Robert Shapiro, Bacteriologist, and Frank E. Hale, Director of Laboratories, Department of Water Supply, Gas, and Electricity, New York City, was read by Mr. Hale. The paper was discussed by L. C. Setter and J. E. Kerslake.

A paper, "Improving the Operation of Rapid Sand Filters," was read by John R. Baylis, Physical Chemist, Department of Public Works, Chicago. Elwood L. Bean discussed the paper.

A paper, "Some Recent Developments in British Water Works Practise," was read by Harold J. F. Gourley, Past President, Institution of Water Engineers, and Consulting Engineer, Binnie, Deacon, and Gourley, London, England. The paper was discussed by Messrs. Malcolm Piernie, Consulting Engineer, New York, N. Y.; Caleb Mills Saville, Manager and Chief Engineer, Water Bureau, Metropolitan District Commission, Hartford, conn.; Karl R. Kennison, Assistant Chief Engineer, Metropolitan District Water Supply Commission, Boston, Mass.; and Robert E. Horton, Consulting Hydraulic Engineer, Vorheesville, N. Y.

Upon motion from the floor the thanks of the Association was extended to Mr. Gourley for his paper and his presence and he was asked to extend to the Institution of Water Engineers the greetings of the Association.

Afternoon Session.

Mr. Walter H. Smith of the Industrial Relations Unit of the Federal Government gave a talk concerning the Back to Business Movement.

The Committee on "The Advisability of Water Departments Regulating Water Piping and Fixtures Within Buildings" presented its report.

This report was discussed by President Esty, Charles W. Sherman, Donald C. Calderwood, Arthur L. Shaw, Charles R. Cox, Arthur V. Harrington, Paul F. Howard, Percy A. Shaw, David A. Hefferman, E. P. Stewart and Hugh McLean.

SUPERINTENDENTS' SESSION.

A paper, "Free Water," was read by J. McClure Wardle, Superintendent, Public Works, Hudson, N. Y.

A paper, "The Use of Couplings," was read by Rossiter S. Scott, Consulting Water Engineer, S. R. Dresser Manufacturing Company, Bradford, Pa. President Esty discussed the paper.

A paper, "Activated Carbon—The Water Purifier," was read by E. A. Sigworth, Water Purification Division, Industrial Chemical Sales Company, Inc., New York City. Percy A. Shaw, William A. MacKenzie, and Theodore L. Bristol took part in the discussion.

A paper, "A Slow Sand Filter Built by FERA Labor," was read by Harold L. Field, Engineer and Superintendent, Water Department, Greenfield, Mass. A written discussion on this paper was submitted by Robert Spurr Weston.

FRIDAY, SEPTEMBER 25.

Morning Session.

PRESIDENTIAL ADDRESS.

BY ROGER W. ESTY, Retiring President.

Fifty-five years ago, several progressive water works men in New England felt that they should get together once in a while and talk over their problems, exchange ideas, and visit other water works plants, to improve not only their own knowledge but that of others interested in water works matters.

The NEW ENGLAND WATER WORKS ASSOCIATION was formed in 1882 with twenty-eight charter members, Mr. John Lyons of Salem, Massachusetts, being the first president. From then on the Association grew rapidly, taking into its organization superintendents and other employees of municipal and private water companies, consulting engineers, contractors, manufacturers, and their various representatives. Today the membership is international in scope with approximately 800 members in the organization.

During the past few years it has been necessary to drop several members for nonpayment of dues, but with the new members coming in, the membership has held its own. At the present time a great many applications are being received and the advertising, particularly, has increased considerably. This alone is an indication that the depression is now history and that the organization may look into the future with a great deal of anticipation for a larger membership. I wish most to emphatically bring before the members of this organization the important part that the manufacturers play within our financial structure. They pay, through the advertisements that they place in our JOURNAL, approximately 30 per cent. of our total revenue. Our income averages about $10 000 per year, therefore they pay into the Association approximately $3 000. This is an important

contribution towards the operating expenses of this organization. They also make it possible for the members and guests of this organization to enjoy a most splendid entertainment program at the time of the convention. The cost of this is about equal to the amount that is paid in dues by the members each year.

Therefore, it seems to me logical and reasonable that the members in lieu of this support given by the manufacturers, should endeavor in every way possible to patronize those who support our organization so generously. When you return home from this convention consult the last issue of the NEW ENGLAND WATER WORKS ASSOCIATION JOURNAL and see if you are doing your part toward making your purchases from the manufacturers who advertise in our Journal.

Mr. Harold L. Brigham has labored energetically as Chairman of the Membership Committee to procure new members. He, like a lot of others, feels it a real honor to serve the Association in such a manner, and without compensation. His work is showing results as many new members have joined the Association, and with better times with us now we should see a greater increase in the future. I ask that every member delegate himself as a committee of one and bring in at least one new member during 1937.

The meetings during the past year have been well attended, with the exception that when the flood conditions were so extensive in New England in March only those in or near Boston could attend.

The members who were asked to participate in monthly programs coöperated splendily, and this was greatly appreciated by the Chairman of the Program Committee..

The Hartford, Connecticut, committee, and the Concord, New Hampshire, committee worked hard and provided splendid technical and sightseeing programs at our Spring meetings. I wish to again extend to them my sincere thanks.

While speaking about the program of the past year I would like to pause a moment or two and pay a tribute to one of our members. In every organization there is always some one who seems to tower above all others through his enthusiasm, perseverance and integrity. He is the spark plug that provides the power, the kick, the life that is so necessary for success. If you but just look back over our programs you will probably realize now how much thought, worry and effort went into them to make them the success that they have been. Many, many hours have been spent in obtaining speakers and in arranging the program. Telephone messages, telegrams, train and bus trips, as well as the use of the automobile has been necessary to bring about all of the factors which dominate the successful program. I wish to take this opportunity to express my sincere appreciation to Mr. E. Sherman Chase, Chairman of the 1936 Program Committee of one (and I don't know how many years back he has held that exalted position) for the splendid and efficient manner in which he has arranged the many programs that were necessary during the past year. In expressing these

personal sentiments I know that I am also expressing the same sentiments from the membership of this most wonderful organization.

The September issue of 1935 was devoted entirely to the report of a committee entitled, "Pipe Line Friction Coëfficients," headed by Elson T. Killam of New York as Chairman. It will be only by the passing of the years that we shall fully realize the importance that this report will play in better pipe lines. There have been so many requests for this report that it recently became necessary to print a second edition, and these are now available at the office of the Association in Boston.

To those who have not seen our office in the Statler Building in Boston we extend an invitation to visit it and make use of the library there, as well as using it as an information bureau when in Boston.

During the winter months, at one of our monthly meetings, we extended an invitation to the Fire Chiefs of New England and a great many attended our specially arranged program. We felt that by this gesture closer coöperation between the two organizations could be had. By an exchange of ideas between the two we come to realize how much each depends on the other, particularly the Fire Department upon the Water Department, for without water the Fire Department is helpless. While we are not so flashy and spectacular as the Fire Department as it dashes down the main street with whistles, bells, and sirens screeching, decked out in brass buttons and gold braid, we still feel that we are an important cog in the community life.

The flood that visited various sections of the Eastern States has impressed upon me the necessity of every community having some other source of supply to draw from if the main plant is put out of commission. Wherever it is possible all neighboring cities and towns should be connected with each other by a pipe line of sufficient size to carry in all or in part the entire demands required. This was forcibly brought to my attention this year when the Lawrence, Mass., filtration plant was put temporarily out of commission due to the highest flood waters in the history of the Merrimac River. Due to being interconnected with North Andover, Andover, Methuen, and Salem, N. H., and supplemented with fire hose and fire pumping engines, these sources of supply were brought into the Lawrence system. These connections surely saved the day for Lawrence while they frantically labored with a large force of men to get their filtration plant back in operation.

Perhaps we are all acquainted with the set-up the Fire Departments have in sending equipment to their neighboring cities and towns in case of an emergency. So should the Water Departments have pipe lines connecting them with their neighbors, and also assist with equipment and man power. Have we done everything possible in this respect? When you return check up your plans and see if you have done everything possible in preventing a water shortage in case a catastrophe should visit you or your neighbor.

Few realize the important part that was played by the officials of the State Departments of Public Health. Their organizations were everywhere working day and night assisting every water works man who was in trouble. Words never can express the appreciation of those water works men to these public health officials.

One thing that has interested me for some time is the protection of the municipal employees from the ruthless political parasites who are a great many times not interested in their citizens' welfare, but in selfish gain only. It is a difficult subject for an organization of this kind to attempt to judge the merits of such cases, but it should express itself emphatically as being very much opposed to the turning out of office of water works men. Few politicians realize the seriousness of discharging a highly qualified man, as for instance, in a filtration plant, and placing in his stead a political friend unqualified for this important position. Few citizens, or the water works man himself, realize how important he is in the everyday community life. He is supposed to have plenty of water in reserve safe against objectionable bacteria, and his distribution system of ample size to provide for its needs as well as for fire protection. It takes years of study, planning and construction to realize all of this.

A water works official should conduct himself in a manner befitting the position he holds, divorce himself from all political affiliations, and devote all of his time and interest to an ample and safe water supply for the people he serves.

I have also been interested in his future when his active days are over. It seems to me that some form of pension should be provided to make it easier when he grows old. A special committee was appointed in Massachusetts to investigate, formulate, and endeavor to enact into law a contributory pension law. We found that the Massachusetts Legislature had already appointed a special committee to look into this matter and report back to the incoming legislative seesion. Springfield and Malden had formulated bills to present before the Legislature, but waited until this committee reported, and when this bill known as House Bill 1501 was reported it seemed to meet as near an ideal as possible. This bill was enacted into law in the state of Massachusetts this year and is known as Chapter 463 of the General Laws of 1936. It will automatically go on the ballot this fall in towns and cities with a population of 10 000 or over.

It has come to my attention through good authority that the State of Massachusetts is going to attempt to pass a tax law making $25 per thousand the maximum tax rate. From this source of information I was told that within three years all municipal electric and water receipts would be taken and used to make the $25 tax rate a reality. All surpluses will be used to help fill up the general treasury pot to be used in most instances by the politically minded to make a showing in other departments. The protection of the health of the citizens and the safety of their property may be jeopardized by this movement, and I sincerely believe that this Associa-

tion and the water works superintendents should record themselves as being opposed to any such move toward such centralization of government. What we need is more home rule, more self government, and we should all lend our influence and energy toward that end and ideal.

In closing I wish to express to the many who have assisted me on the various committees my sincere appreciation for their loyal and helpful coöperation.

It has been a pleasant experience to serve you as president, and one that shall never be forgotten.

I trust that you all will be as loyal to my successor, Mr. Harry Fuller, our incoming president. [Applause.]

A paper, "Pipe Linings," was read by Thomas F. Wolfe, Research Engineer, Cast Iron Pipe Research Association, Chicago, Ill. E. T. Cranch, S. H. Taylor, David E. Moulton, Percy A. Show, Michael E. Quirk, David A. Heffernan, and Roger E. Oakman took part in the discussion.

A paper, "A Rapid Sand-Filter Built by WPA Labor," was read by W. Guy Classon, Superintendent and Registrar, Water Department, Leominster, Mass.

Superintendents' Round Table.

Topic: *Street Mains and Service.*

This discussion was led by the reading of a paper prepared by Samuel H. MacKenzie, Engineer and Superintendent, Southington Water Department and Terryville Water Company, Southington, Conn., and participated in by Laurence C. Hough, David F. Moulton, William Naylor, David A. Heffernan, Harry U. Fuller, W. C. Hawley, William A. MacKenzie, Allan F. McAlary, and Donald C. Calderwood.

Topic: *What Factors Determine the Proper Size of Street Main or Service Pipe?*

This discussion was led by Elson T. Killam, Associate Engineer, Alexander Potter, Consulting Engineer, New York City, and participated in by Stephen H. Taylor, Horace L. Clark, and David A. Heffernan.

Topic: *Rigid Versus Flexible Service Connections.*

The discussion was led by Arthur C. King, Superintendent, Taunton Water Works, Taunton, Mass. Harry U. Fuller, Donald C. Calderwood, Percy A. Shaw, William Naylor, and David A. Heffernan took part.

Topic: *Meter Masters, the "G-Men" of the Water Works.*

President Roger W. Esty, Percy A. Shaw, Superintendent, Manchester Water Works, Manchester, N. H., Harold W. Griswold, Deputy Chief

Engineer, Water Bureau, Metropolitan District of Hartford County, Connecticut, and Horace L. Clark, Superintendent, Sanford Water Company, Sanford, Maine, took part in the discussion.

Report of Tellers of Election.

The tellers submitted the following report:

Total number of ballots cast	214
For President, Harry U. Fuller	213
For Vice President, George A. Sampson	214
For Director, Francis H. Kingsbury	214
For Treasurer, Leland G. Carlton	214

(Signed)

Joseph E. Moore,
Maurice A. Libby,
Charles J. Crump,
Chairman.

Introduction of New President.

David E. Moulton. Mr. President and gentlemen: It is a peculiar satisfaction to me to have the privilege of introducing to you a man who I believe is the first president of this Association from the state of Maine. It is a satisfaction to me to have this privilege because for the past twenty years Mr. Fuller and I have been in perpetual, almost daily debates, it being my purpose to impress him with the fact that the legal department of a water works is as important as the engineering. I have never been able to convince him. [Laughter.] He has one other heresy. He thinks the proceedings and reports of the New England Water Works Association are infallible. And so our discussions usually wind up with his producing some report from this Association and I am supposed to consider it *res adjudicata*.

And so I have the privilege of presenting as your president for the next year a graduate of the New England Water Works Association, Mr. Harry U. Fuller. [Applause.]

Mr. Fuller. Mr. President, Mr. Moulton, and gentlemen: I think that I can say to you at this time just this much: I appreciate your confidence and I thank you for the opportunity to serve you. [Applause.]

Presentation of Gift to Retiring President.

Secretary Gifford. I think this is the first time that I have spoken during the convention. This time I have been asked to talk. As your secretary I have many duties, but I have had no pleasanter task assigned to me than that for which I am breaking my vow that I would talk no more.

If you will look back at the pages of your Journal you will find a long list of names of men distinguished not only in the water works practice

but in the consulting field, names that have an international singificance. I have been connected with the association in an official capacity for—I would rather not tell you how long, but about thirty years, I would say, the last seventeen of which have been as your secretary. I have been associated with your presidents very closely during that time and they are numbered among my friends. The presidents have done extraordinarily good work, but I want to say to you that during my experience there has been no president of this Association who has put in so much time and effort, and worked so conscientiously for the good of the Association, as has your just retiring president, Roger W. Esty. [Applause.]

Roger has many friends. He has—what shall I say?—constant good nature. He is smiling now, and that is the way he is all the time. He has made many friends not only outside the Association but in the Association, and a small number of his friends have asked me, they knowing of his enthusiasm for making records, as he has shown you all—he is now getting physical records in the form of pictures—if I would present this token of their appreciation to Roger, with the hope and thought that he would continue his good work, knowing well he would, but that it would give him pleasure rather than the duty which he has been encumbered with during this past year.

It is with a great deal of pleasure, Roger, that I hand you this movie camera from your well-wishers and friends. [Applause.]

President Esty. Mr. Gifford and friends: This is indeed a surprise to me. You may rest assured that being your president has been one of the most pleasant duties that I have ever been called upon to perform.

I thank you all. If there is no further business I will declare the Fifty-fifth Annual Convention of the New England Water Works Association closed.

[Adjourned]

Annual Report of the Secretary.

Mr. President and Gentlemen of the New England Water Works Association:—The Secretary submits herewith the following report of the changes in membership during the past fiscal year, and the general condition of the Association.

The present membership is 760, constituted as follows: 13 Honorary Members, 633 Members, 94 Associate Members, and 20 Corporate Members. The detailed changes are as follows:

MEMBERSHIP.

September 1, 1935. Honorary Members		12		
Withdrawals:				
Died		1	11	
Elected:				
September, 1935			2	13
September 1, 1935. Members, Total			652	
(An error of 11 members was listed in report of September, 1935.)				
Withdrawals:				
Resigned		16		
Died		6		
Dropped by Executive Committee		39		
Elected to Honorary Membership		2	63	589
Elected:				
September, 1935		20		
November, 1935		2		
December, 1935		3		
January, 1936		1		
February, 1936		3		
March, 1936		5		
August, 1936		11		45
Reinstated:				0 634
September 1, 1935. Juniors, Total			0	
September 1, 1936. Juniors, Total			0	0
September 1, 1935. Associates, Total			86	
Withdrawals:				
Dropped by Executive Committee		1		85
Elected:				
September, 1935				7
February, 1936				1
August, 1936				1 94
September 1, 1935. Corporates, Total			18	
Elected:				
April, 1936			1	
August, 1936			1	20

September 1, 1935. Total Membership	768
September 1, 1936. Total Membership	761
Net Loss	7

ELECTIONS.

Honorary Members.

September 17, 1935. Stephen H. Taylor and Frank E. Winsor. (2)

Members.

September 17, 1935. Harry H. Angell, James F. Brittain, Charles L. Coburn, Carter S. Cole, Charles B. Cole, James J. Dillon, Stanley M. Dore, George F. Gardiner, Thomas E. Harding, Charles F. Jost, Adolph La Fleur, Albert J. Lamarre, Arthur O. Lavalley, John W. Logan, Edward A. McLaughlin, W. J. C. Marshall, Raymond E. Snow, Joseph P. Wadhams, Lewis L. Wadsworth, and Joseph Wuraftic. (20)

November 21, 1935. Howard E. Bailey and Merritt E. Cutting. (2)

December 19, 1935. Robert P. Johnson, Charles O. Baird, Jr. and Harry H. Smith. (3)

January 16, 1936. Edgar K. Wilson. (1)

February 20, 1936. Justus W. Patterson, Leonard Dominque, and Alexander J. Minkus. (3)

March 19, 1936. Charles E. Greene, Philip P. Welch, Howard H. Potter, (by letter ballot) Allen J. Burdoin, and Donald P. Johnston. (5)

August 7, 1936. George V. Clapp, Henry F. Ferrick, A. Leland Glidden, (by letter ballot) John F. McVey, Jr., Joseph A. Ross, Ralph M. Soule, and Raymond F. Wagner. (6)

August 27, 1936. John R. Baylis, Allan S. Beale, Thomas C. Flinn, and Robert W. Mawney. (4)

Associates.

September 17, 1935. Brainard & Hatch, The Foxboro Company, Hedge & Mattheis Company, Industrial Chemical Sales Company, W. C. Lipe, Inc., Merrimac Chemical Company, and Syntron Company. (7)

February 20, 1936. Turbine Equipment Co. of New England. (1)

August 7, 1936. Reppucci & Co. (1)

Corporates.

April 28, 1936. Board of Water Commissioners, Gloucester, Mass. (1)

August 27, 1936. Northampton Board of Water Commissioners, Northampton, Mass. (1)

RESIGNATIONS AND DEATHS.

Members.

Resigned: S. A. Agnew, W. C. Campbell, G. A. Chamberlain, F. P. Close, F. M. Cole, C. R. Gow, R. C. Harris, J. J. Healy, Jr., B. C. Little, W. C. Louisbury, J. W. Nolan, W. W. Nye, A. G. Picher, H. P. Reynolds, H. E. Weeks, and W. S. Wyman. (16)

Dropped for non-payment of dues: R. C. Allen, C. R. Barker, C. A. Bingham, P. E. Bond, L. A. Bridges, J. S. Caldwell, R. F. Campbell, F. T. Coffin, F. A. Cole, F. J. Driscoll, J. J. Ducey, S. Dyer, E. H. Eldredge, M. E. Flentje, M. G. Hall, N. LeR. Hammond, L. J. Hathaway, Jr., A. A. Higgins, W. V. Howes, A. Koch,

A. S. Malcomson, A. J. Masefield, A. S. Merrill, C. E. Miller, C. W. Mills, A. W, Moore, J. W. Moran, C. O. Murphy, W. Plattner, L. Priest, P. M. Putnam, R. L. Reed, F. H. Rose, F. O. Stevens, S. B. Storey, T. H. Stothart, J. W. Vaughan, I. S. Walker, and G. Webster. (39)

Died: E. G. Bradbury, E. M. Byington, E. W. Clarke, H. V. Gates A. B. Mauzy, R. B. Morse. (6)

Honorary Members.

Died: Fayette F. Forbes. (1)

Associates.

Dropped for non-payment of dues: The Fairbanks Company. (1)

RECEIPTS FOR THE FISCAL YEAR, SEPTEMBER 1, 1935 to SEPTEMBER 1, 1936.

Entrance Fees			$162.00
Annual Dues:			
Members	$3 177.97		
Corporates	165.00		
Associates	1 670.00	$5 012.97	
Fractional Dues:			
Members	$ 38.50		
Corporates	7.50	46.00	
Past Dues:			
Members	$ 304.00		
Corporates	10.00		
Associates	100.00	414.00	
1936–1937 Dues:			
Members	$ 3.00		
Corporates	10.00	13.00	
Total Dues			5 485.97
Dividends			463.23
Advertisements			3 054.60
Subscriptions			515.95
JOURNALS			207.19
Reprints			582.32
Transfer from Savings Bank			700.00
Sundries			268.34
Total Receipts			$11 439.60
There is due the Association:			
Dues		$ 338.00	
Advertisements		130.00	
JOURNALS		7.75	
Reprints		98.75	
Membership List		1.00	
Subscriptions		20.00	595.50
Total			$12 035.10

Respectfully submitted,

(Signed) FRANK J. GIFFORD, *Secretary.*

Annual Report of the Treasurer.

September 1, 1935 to August 31, 1936.

The President and Members of the New England Water Works Association:— I herewith submit as my report for the year ending August 31, 1934, the following statement from Scovell, Wellington & Co., accountants.

Respectfully submitted,
(Signed) Leland G. Carlton, *Treasurer.*

Springfield, September 11, 1936.

Leland G. Carlton, *Treasurer,*
New England Water Works Association,
Springfield, Massachusetts.

Dear Sir: In accordance with your request, we have made an examination of the accounts and financial records of the New England Water Works Association for the year ended August 31, 1936.

We submit herewith the following attached statements:

Exhibit A. Statement of Assets and Funds as at August 31, 1936.

Exhibit B. Statement of Receipts and Disbursements, General Fund, for the Year ended August 31, 1936.

We traced all recorded receipts to the depository bank, verified the general fund bank account and petty cash fund as at August 31, 1936 and examined properly approved vouchers for all disbursements.

We also verified by direct confirmation the balances of invested funds in the various savings bank accounts.

Respectfully submitted,
(Signed) Scovell, Wellington & Company.

EXHIBIT A.

Statement of Assets and Funds.
As at August 31, 1936.

Assets.

Cash in Banks, Invested Funds:		
City Five Cents Saving Bank, Haverhill, Mass.	$2 000.00	
Farmers and Mechanics Savings Bank, Framingham, Mass.	2 068.46	
Franklin Savings Bank, Boston, Mass.	2 000.00	
Haverhill Savings Bank, Haverhill, Mass.	2 000.00	
Home Savings Bank, Boston, Mass.	311.25	
Mechanics Savings Bank, Reading, Mass.	2 000.00	
Pentucket Savings Bank, Haverhill, Mass.	2 000.00	
Peoples Savings Bank, Worcester, Mass.	2 000.00	
Suffolk Savings Bank, Boston, Mass.	2 000.00	
Total Invested Cash		$16,379.71
General Fund:		
Cash, First National Bank of Boston	$ 239.53	
Cash in Office	50.00	
		289.53
Forward		$16 669.24

Brought Forward		$16 669.24
Furniture and Fixtures		1 113.50
Total Assets		$17 782.74

Funds.

Invested Funds		$16 379.71
General Fund:		
Balance, August 31, 1935	$1 588.99	
Add: Transfer from Home Invested Funds during year	700.00	
	$2 288.99	
Deduct: Excess of Disbursements over Receipts, Exhibit B	885.96	
Balance, August 31, 1936		1 403.03
Total Funds		$17 782.74

NOTE:— The above statement is prepared on a cash basis and does not reflect the following:

Accounts Receivable, Dues	$ 338.00
Due on Account of Advertising and other Miscellaneous Charges	257.50
	$ 595.50
Accounts Payable	$ 504.50
Dues and Subscriptions Paid in Advance	66.00
	$ 570.50

No Depreciation has been taken on Furniture and Fixtures.

EXHIBIT B.

STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS.
GENERAL FUND.
For the Year ended August 31, 1936.

Receipts.

Initiation Fees		$ 162.00
Dues		5 485.97
Interest		463.23
From Publication of JOURNAL:		
Advertisements	$3 054.60	
Subscriptions	515.95	
Sale of JOURNAL	207.19	
Sale of Reprints	582.32	
Sale of Halftones, Electros, etc.	21.04	4 381.10
Forward		$10 492.30

Brought Forward		$10 492.30	
Miscellaneous:			
Membership Certificates	$ 6.00		
Receipts for Outing	203.00		
Miscellaneous	23.85	232.85	
Total Receipts			$10 725 15

Disbursements.

Publication of JOURNAL:			
Printing	$3 614.77		
Plates	618.40		
Reporting	455.97		
Reprints	485.33		
Stationery and Postage	167.98		
Editor's Salary	500.00		
Editor's Expense	2.85		
Sundries	35.38	$5 880.68	
Office and General:			
Certificate of Membership	$ 29.92		
Engineering Society of New England	349.24		
Secretary's Salary	400.00		
Assistant Secretary's Salary	1 062.99		
Secretary's Expense	86.97		
Treasurer's Salary	100.00		
Treasurer's Bond	5.00		
Printing, Postage and Stationery	336.70		
Office Rent	1 200.00		
Electricity and Towel Service	40.55		
Telephone and Telegraph	164.64		
Audit	65.00		
Exchange	5.76		
Membership Lists	467.00		
Sundries	150.12	4 463.89	
Meetings and Committees:			
Badges	$ 42.85		
Medal	15.13		
Printing, Postage and Stationery	451.80		
Stereopticon	55.00		
Committee Expense	415.75		
Convention Expense	82.81		
Outing Expense	142.50		
Miscellaneous Expense	60.70	1 266.54	
Total Disbursements			11 611.11
Excess of Disbursements over Receipts, Exhibit A			$ 885.96
Transfer from Invested Funds during year		$ 700.00	
Balance, General Cash, August 31, 1935		475.49	1 175.49
Balance, General Cash, August 31, 1936:			
Represented by Cash in General Bank Account		$ 239.53	
Represented by Cash in Office		50.00	
			$ 289.53

Annual Report of the Editor.

To the New England Water Works Association: The Editor submits herewith the following report for the year ending August 31, 1936.

As has been customary in the past, the tables of financial figures, accompanying the report, are based upon total charges and accounts receivable, ather than actual cash received or disbursed. A detailed statement of the receipts and disbursements on account of the September and December, 1935, and March and June, 1936, issues of the Journal is included in the Report of the Treasurer.

Table 1 is a statement of the material published.

Table 2 gives a comparison of the Journal for the past year with preceding years.

Size. The four issues contained 642 pages, of which 477 were text.

Cost. The gross cost of the Journal was $5 880.68, equivalent to $7.64 per member; the net cost was $1 499.58, equivalent to $1.97 per member.

Reprints. Reprints of each paper have been furnished to the author at cost.

Circulation. The present circulation of the Journal is:

Members, all grades	760
Subscribers	127
Exchanges	16
Total	903

(Journals have been sent to all subscribers.)

Respectfully submitted,

Gordon M. Fair, *Editor.*

Table 1.

Statement of Material in September and December, 1935, and March and June 1936, Issues of the Journal of the New England Water Works Association.

Date.	Pages of.								
	Papers.	Proceedings.	Total Text.	Index.	Advertisements.	Cover and Contents.	Insert Plates.	Total.	Total Cuts.
September, 1935	110	0	110	0	39	7	0	156	26
December, 1935	83	35	118	9	39	5	0	162	15
March, 1936	105	6	110	0	39	5	0	164	20
June, 1936	128	10	138	0	41	5	0	184	45
Total	426	51	477	9	158	17	0	642	116

TABLE 2.

COMPARISON OF JOURNALS OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

	FOUR ISSUES FOR FISCAL YEAR ENDING AUG. 31									
	1927.	1928.	1929.	1930.	1931.*	1932.	1933.	1934.	1935.	1936.
Average edition (copies printed)	1 100	1 138	1 200	1 350	1 260	1 200	1 125	1 100	1 100	1 100
Average membership	784	808	831	822	816	813	805	796	786	770
Circulation at end of year	916	955	993	980	955	957	930	928	918	903
Pages of text	492	528	507	570	410	437	420	499	470	477
Pages of text per 1 000 members	628	654	610	693	502	537	522	627	598	619
Total pages, all kinds	724	769	745	812	682	644	594	645	643	642
Total pages per 1 000 members	952	952	896	988	836	790	738	811	808	834
GROSS COST:										
Total	$5 839.36	$6 849.44	$6 740.87	$8 054.59	$6 135.33	$5 024.03	$4 712.16	$5 411.30	$4 780.75	$5 880.68
Per page	8.07	8.91	9.06	9.92	9.00	7.80	7.93	8.39	7.54	9.16
Per member	7.45	8.48	8.12	9.80	7.52	6.18	5.85	6.80	6.08	7.64
Per member per 1 000 pages	10.29	11.02	9.77	12.07	9.00	9.62	9.85	10.53	9.46	11.89
Per member per 1 000 pages text	15.13	16.06	16.01	17.19	18.34	14.30	13.94	13.62	12.93	16.01
NET COST:										
Total	$710.63	$1 716.25	$1 857.58	$3 664.76	$1 252.21	$1 121.20	$1 176.77	$1 916.27	$1 332.99	$1 499.58
Per page	.98	2.23	2.07	4.51	1.84	1.74	1.98	2.97	2.07	2.34
Per member	.91	2.12	2.24	4.46	1.53	1.38	1.46	2.41	1.70	1.95
Per member per 1 000 pages	1.26	2.76	2.50	5.49	2.24	2.14	2.46	3.73	2.64	3.03
Per member per 1 000 pages text	1.85	4.02	4.41	7.82	3.73	3.16	3.48	4.83	3.61	4.08

*Including Comprehensive Index, 1882 to 1930.

Report of Finance Committee.

September 14, 1936.

To the Executive Committee of the New England Water Works Association:

Gentlemen: The Finance Committee submits the following budget for the fiscal year ending August 31, 1936:

	Expended 1935-1936	Recommended 1936-1937
Journal	$ 5 880.68	$ 4 500.00
Office	4 433.34	4 200.00
Meetings and Committees	1 311.54	1 500.00
Total	$11 625.56	$10 200.00

In order to provide funds to take care of unpaid salaries for 1936, provide additional funds to take care of some form of a water works school and allot amounts which can be reasonably expected to be sufficient to overcome another yearly deficit, a slightly increased budget is recommended even though the recommendations of last year's finance committee become effective in reducing expenditures by eliminating free reprints of Journal articles and the dues in the New England Engineering Society.

As is now customary, an audit of the books has been made by a certified public accountant whose report is made part of the Treasurer's Report.

Respectfully submitted,

(Signed) William B. Duffy, *Chairman*,
William A. MacKenzie,
John H. Read.

Report of Committee on Water Main Disinfection.

At the annual meeting on September 23, 1930 this committee under the leadership of Mr. E. Sherman Chase presented a progress report of its activities. This report included a summary of material gained from questionnaires which had been submitted at the request of the committee by a number of water works men located in different sections of the country. The information showed that a large proportion of water works superintendents considered the disinfection of newly laid water mains a desirable treatment.

For many years, both before 1930 and since, various journals have published many discussions which stress the importance of water main sterilization and have described various methods and treatments that may be used under different local conditions. Practically all of the methods provide for the use of chlorine followed by thorough flushing and controlled by bacteriological examinations or by tests for residual chlorine. Appended to this report is a bibliography and a brief summary of the essential data contained in these references.

The progress report of this committee concluded as follows:

It is true that in many water works no disinfection of water mains has ever been carried out and, so far as information is available, without serious water main contamination. It must be remembered, however, that no one can foresee when disastrous contamination may result through unfortunate combinations of circumstances. For this reason it seems as though the precaution of disinfecting newly-laid water mains were worthwhile and we wish to leave this thought with our fellow members of the Association.

As expressed in this previous report, the committee feels that the disinfection of newly-laid water mains is a necessary sanitary precaution, and therefore makes the following recommendations:

1. That proper precautions be taken to prevent the contamination of sections of water pipe when stored or placed along a trench before installation.
2. That all water mains that have undergone construction work be treated with chlorine, sufficient to yield a residual of at least 2.0 p.p.m. after a period of contact of 24 hours.
3. That the mains be thoroughly flushed after treatment.
4. That when possible a report of the bacteriological examination of water from the main after treatment be obtained before the main is placed in use.
5. That the method of treatment and application of the chlorine be selected on the basis of the requirements of the local conditions.

Respectfully submitted,

F. Wellington Gilcreas, *Chairman.*
Thomas E. Lally.

Author.	Source of Information.	Sterilizing Agent.	Dose.
Anonymous	Eng. News (1897) 327	$CaOCl_2$	....
Hoover & Scott	Eng. Rec. *68*:11,257 (1913)	$Ca(OH)_2$	....
Rich	Eng. News Rec. *91*:11,431 (1923)	$CaOCl_2$	15 p.p.m.
Absher	J. A. W. W. A. *15* 52 (1926)	Liq Cl	....
Brush	J. A. W. W. A. *17* 79 (1927)	$CaOCl_2$	½ oz. per section
Brush	J. A. W. W. A. *17* 79 (1927)	Liq Cl	....
Eastwood	J. A. W. W. A. *18* 114 (1927)	$CaOCl_2$	1 oz. per section
Eastwood	J. A. W. W. A. *18* 114 (1927)	Liq Cl	10–20 p.p.m.
Gorman	Water Wks. LXVI; 8,326 (1927)	Liq Cl	....
Anonymous	Munic News & W. Wks. *75*:2,84 (1928)	Liq Cl	....
McClintock	W. W. Eng. *82*:12 (1929)	$CaOCl_2$	1 lb. to 8 sections
Strohmeyer	Surveyor *76* 147 (1929)	(100 p.p.m.) $CaOCl_2$ or Liq Cl	0.6 lb. Cl to 100 cu. ft. of pipe volume
Cook	W. W. Eng. *83* 1157 (1930)	$CaOCl_2$	2 lb. per m.g. of pipe content
Gray	W. W. Eng. *83* 1157 (1930)	....	....
Hunter	W. W. Eng. *83* 1157 (1930)	Liq Cl	....
Luippold	Ariz. Bd. Health Bull. 54 July 1930	Liq Cl	0.5–10 p.p.m.
St. John	Am. City *43* 104 (1930)	Liq Cl	....
Stewart	W. W. & Sew. *77* 191 (1930)	Liq Cl	....
Sweeney	W. W. Eng. *83* 1157 (1930)	Liq Cl	....
Fuller	W. W. & Sew. October 1931	$CaOCl_2$	1 oz. per length
Fuller	W. W. & Sew. October 1931	Liq Cl	....
Griffin	J. N. E. W. W. A. 45,1 (1931)	$CaOCl_2$	3.2 p.p.m.
Griffin	J. N. E. W. W. A. 45,1 (1931)	Liq Cl	8–4 p.p.m.
Lally	Letter to F. W. G. 7.6.35	HTH CCH	....
Chase	Memorandum to Rockport, Mass.	HTH	10 p.p.m. Cl
Metcalf & Eddy per A. L. Fales	Letter to Bethlehem Shipbuilding Co.	$CaOCl_2$	50 p.p.m. Cl
	Health News, N.Y. State Dept. Health *6* 199 (1926)	Liq Cl or $CaOCl_2$	10–20 p.p.m. Cl
Stutzer	Mason: Water Supply, p. 60	H_2SO_4	1 lb. 60° B to 40 imp. gal.

Summary of Data

Residual.	Holding Time.	Method of Application.
....	48 hr.	Mains emptied, lime mixed in reservoir, then applied to mains.
½–1 gr. per gal. caustic alkalinity.	....	Sterilized old work after flood. $Ca(OH)_2$ applied at softening plant. Bacterial confirmation.
....	....	Sterilized old work after flood. $CaOCl_2$ applied to well. Hydrants flushed until satisfactory residual. Bacterial confirmation.
....	....	Cl applied through standard corporation cock, pipe flushed with chlorine water until positive ortho-tolidin test.
....	none	Preliminary brushing; $CaOCl_2$ laid in pipe; pipe filled with water, then blown off. Bacterial confirmation.
73 p.p.m.	24 hr.	Pipe flushed with water; Cl gas added; Bacterial confirmation; tarry taste due to lining.
....	12 hr.	
orange-red with ortho-tolidin.	several hours.	Preliminary flushing, chlorine applied by using the standard corporation cock and silver tube, tapped into main. Used duplicate chlorinator or small tank, chlorinated water run out until orange-red with ortho-tolidin, then held in pipe.
positive odor.	1 hr.	Cl applied through lead pipe and corporation cock, run through until Cl odor is obtained at hydrant and then 1 hr. more.
....	....	Sterilizing contaminated water tunnel shafts. Cl tank used connected to standard diffuser.
....	30 min.	$CaOCl_2$ laid in pipe 1 lb. at every 8th section, filled with water and held 30 min., pipe kept plugged during construction.
....	....	With new work not requiring flushing $CaOCl_2$ is laid in pipe. If flushing is required, Cl is applied by means of a specially designed apparatus. See original article for further details.
....	24 hr.	$CaOCl_2$ laid in pipe during construction.
....	....	
....	24 hr.	Preliminary flushing, Cl then applied through corporation cock, held 24 hr., then flushed.
0.1–1.0 p.p.m.	....	General directions, allow use of direct Cl feed or through chlorinator.
....	4–6 hr.	Portable chlorinator; preliminary flushing, then treatment with Cl water 2–3 hr., allowing 2–3 hr. holding.
2–4 p.p.m.	10 min.	Cl applied through corporation cock either direct or with portable chlorinator.
....	....	Main filled with water, Cl gas applied at inlet, bled at end of line until ortho-tolidin residual is obtained.
....	24 hr.	$CaOCl_2$ laid in pipe during construction. When pipe is up grade water is admitted at low point. Bacterial confirmation.
....	24 hr.	Cl admitted as gas. A valve on each side of Cl inlet is partially opened to provide turbulence.
....	....	Preliminary scrubbing, 2½ lb. $CaOCl_2$ per 100 ft. of 74 in. pipe
2 p.p.m.	24 hr.	Applied by chlorinator at gatehouse; 8 p.p.m. dose first 10 hr., then 4 p.p.m. until end of line had 2 p.p.m. residual.
....	24 hr.	Applied to filling point after line had been tested, accepted, and blown off.
....	....	Sterilization of water tank. HTH dissolved in water, added to tank and tank filled.
....	12 hr.	Sterilization of water system on Airplane Carrier Lexington. Cl solution prepared outside and run into tanks through pipes.
orange-red with ortho-tolidin.	several hours.	Applied through corporation cock and diffuser, $CaOCl_2$ laid in pipe or applied at end of line.
....	....	

BOOK REVIEW.

STANDARD METHODS FOR THE EXAMINATION OF WATER AND SEWAGE. American Public Health Association and American Water Works Association, Eighth Edition, 1936; 309 pp; Cloth; 6¼ x 9¼. Published by American Public Health Association, 50 West 50th Street, New York, N. Y. $2.50.

The previous edition of this valuable book appeared in 1933 and contained 180 pages. Thus, some idea may be gained from the page content of the amount of new material that has been added. In addition many of the old procedures have been completely revised. It is apparent that the Joint Editorial Committee and its collaborators have expended a great amount of effort in getting out the new edition of this volume which means so much to the orderly conduct of water and sewage analysis.

The form or scheme under which material for the various procedures is presented has not been changed but the order of procedures is different. The book is divided into seven parts with various sections and has two appendices. Duplication of methods in the different parts is largely avoided by a system of cross-referencing which has been simplified over previous editions but is still rather awkward and time-consuming in use. There is a question as to whether a system using page numbers would not be more acceptable to most readers.

Such determinations as those for odor, chlorine and turbidity have been re-written and greatly improved. New methods are given for boron, copper, iodide, phosphate, potassium, silica and possibly some others. Most of these now become "standard" methods. Appendix I deals with a long list of "non-standard" procedures, those which have not received general acceptance in laboratory practice.

In Part II, Mineral Examination of Water, the more commonly used mineral tests are arranged, in three groups, those for potable water, those for stationary boiler water and those for municipal and railroad supplies. Many of these have not been materially changed in this edition.

The methods for sewage, effluents, wastes and polluted waters, and for the examination of sludge and mud, have been taken over with editorial revision from the report of the committee of the Federation of Sewage Works Associations which was published in 1935 as "Provisional Standard Methods of Sewage Analysis". Here are grouped such widely different tests as those for ammonia, oxygen consumed and dissolved oxygen.

Microscopical methods for water have been revised and now include the centrifuge method for concentration of microscopic organisms. Microscopical methods for sludge and bottom sediments have been entirely rewritten and are accompanied in Appendix I by an interpretation of studies of bottom sediments.

Section IX of Part VII, Test for the Presence of Members of the Coli-Aerogenes Group, has been rewritten. The material relating to procedure is presented in a much clearer, more concise way. For the confirmed test it is now permissible to use brilliant green bile, crystal violet lactose broth, fuchsin lactose broth or formin ricinoleate broth as well as Endo or eosin methylene blue agar.

The "Most Probable Number" (M. P. N.) is now to be used to record the results of coli-aerogenes tests where multiple portion decimal dilution plantings are made. Tables are given showing the M. P. N. when planting various portions.

The writer has encountered few mistakes in the text. One is the repetition on page 54 of the method given on page 53 for converting parts per million to milli-equivalents Another is in the last two lines on page 53. The meaning is here obscure. Taken as a whole this eighth edition is outstanding among all that have been issued in the scope of its material and in its arrangement. There are some of the procedures that need further investigation without doubt, but the test of further experience will determine their ability to remain as "standard" tests.

The book is bound in attractive red cloth. It is printed on medium weight stock which will withstand moderately well the ravages of laboratory wear.

M. C. WHIPPLE.

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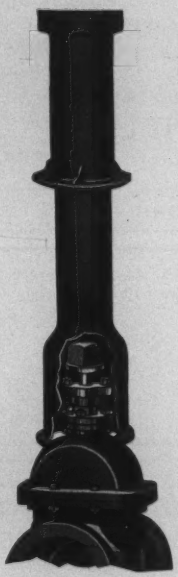

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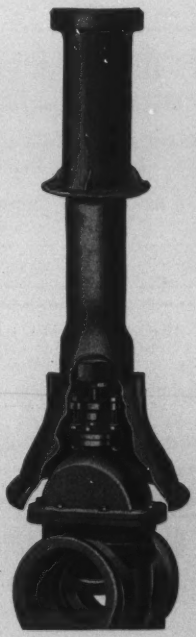

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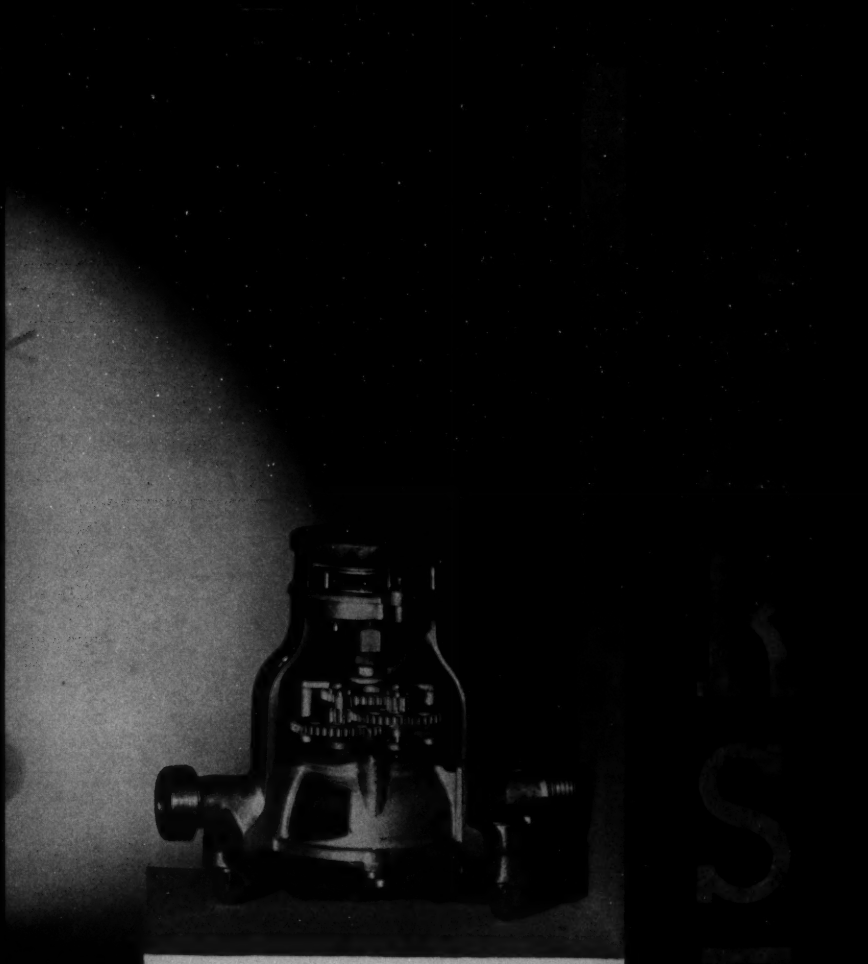

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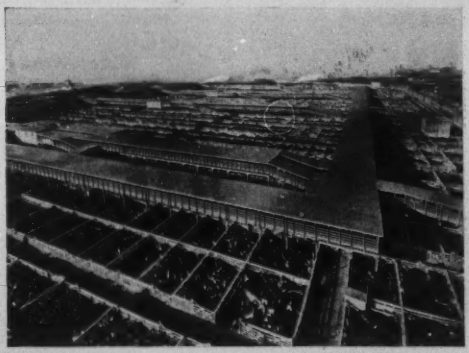

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Kansas City, Kansas, is chiefly an industrial community, sixty per cent of its industrial output being represented in packing house products. It ranks second in the United States as a meat packing center; third in the production of soap; third in grain storage capacity and fifth as a milling center. Other important industries include structural steel, American walnut, lumber, cattle serum and caskets.

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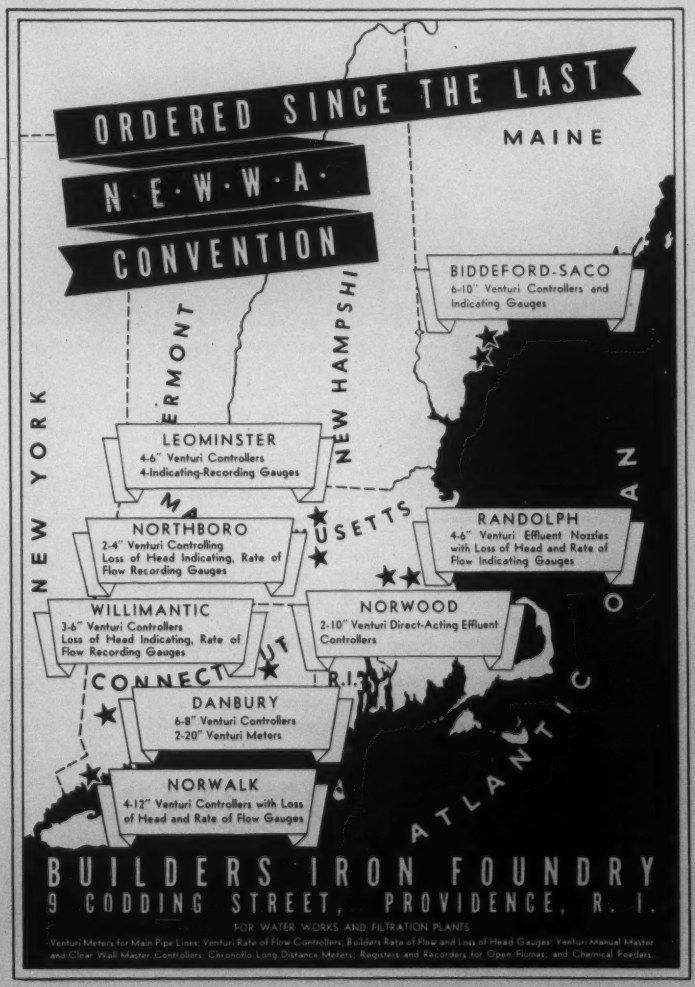
New England Water Works Association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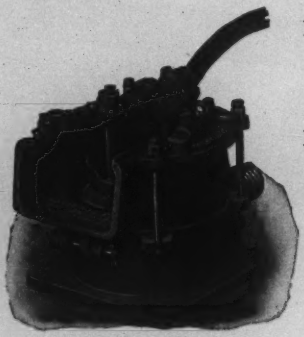

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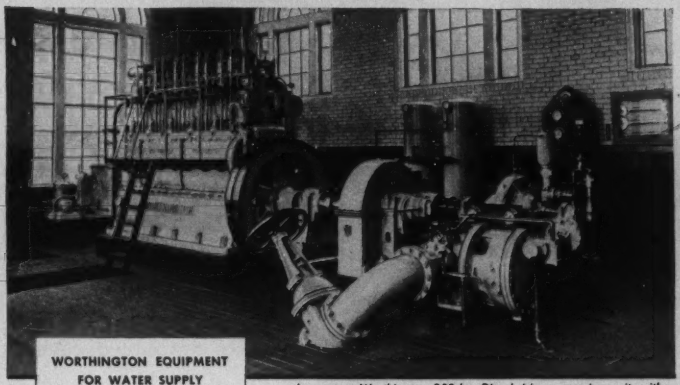

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THIS modern Worthington water works installation is but one of the hundreds which are successfully serving forward-looking communities throughout the country.

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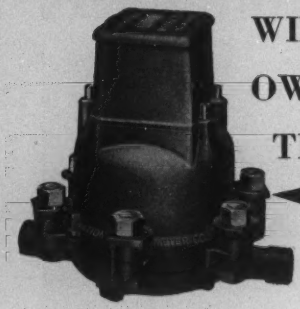

From December through February, thousands of dollars in meter replacement costs are saved each year by the exclusive frost feature of the L. H. Nash Water Meter.

Damage by freezing is confined to the breakage of a few cast-iron washers . . . casing washers easily replaced at a cost as low as six cents a meter.

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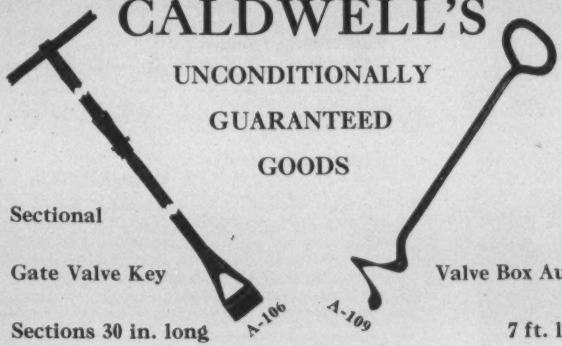

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Easy, positive operation of the Kennedy SAFETOP is assured by its simple straight-line central operating mechanism. In addition, the ample provisions for lubrication, the special long-wearing valves and gaskets, and the double automatic drain valves assure trouble-free service for long periods without attention.

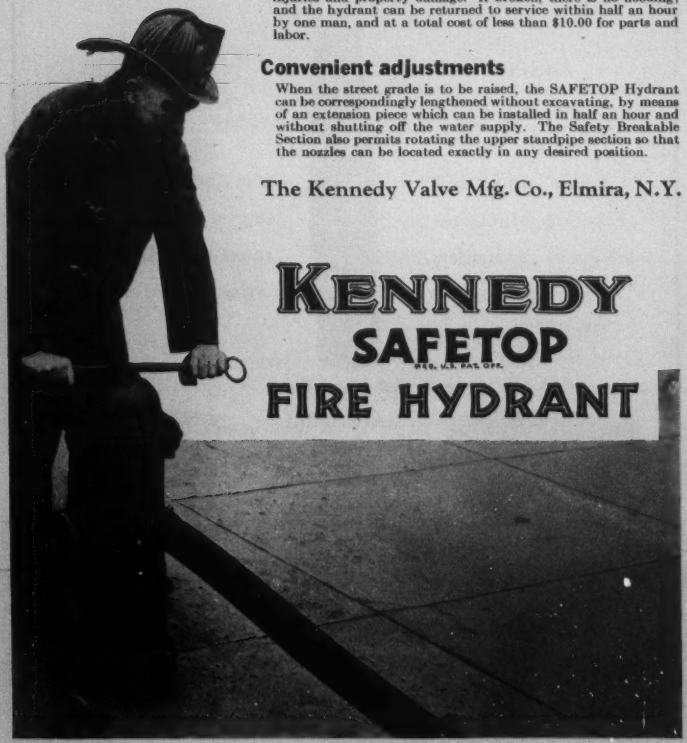
Protection against breakage expenses

The patented Safety Breakable Section protects the major and expensive parts of the hydrant from damage in case of a smashing collision, and also reduces the likelihood of severe personal injuries and property damage. If broken, there is no flooding; and the hydrant can be returned to service within half an hour by one man, and at a total cost of less than $10.00 for parts and labor.

Convenient adjustments

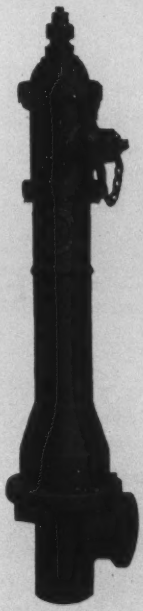
When the street grade is to be raised, the SAFETOP Hydrant can be correspondingly lengthened without excavating, by means of an extension piece which can be installed in half an hour and without shutting off the water supply. The Safety Breakable Section also permits rotating the upper standpipe section so that the nozzles can be located exactly in any desired position.

The Kennedy Valve Mfg. Co., Elmira, N.Y.



EDDY

Valves and Hydrants



Distinctive Features of the EDDY Valves

ONLY three parts are moved by the Stem—the ball and the two gates. Each gate is hung from one of the trunnions on the ball. A convex surface at the base of each trunnion fits a concave surface on the back of the gate. This allows the gates to adjust themselves properly to their seats. . . . The gates, being free to revolve on the trunnions, do not always seat in the same position. Gates are center bearing and adjustable. They are forced to their seats with equal pressure at all points. There are two hooks on the ball on sizes 4-inch and larger, which loosely engage with the gates.

Distinctive Features of Our New Swivel Top Hydrants

THIS new hydrant has all the advantages of the popular EDDY fire hydrant, plus several additional features. . . . Nozzles are in a short flanged section of the standpipe, which may be unbolted and turned to different positions. . . . Should the standpipe be broken, only the casting below the swivel head need be replaced. . . . To raise the hydrant to conform to a new grading, simply insert a flanged extension piece below the swivelhead. No digging. To add a steamer nozzle at any time, it is only necessary to replace the swivel head with one having a steamer nozzle.

Besides valves and hydrants to meet the most exacting demands of waterworks service, the complete EDDY Line includes: valves for sewage disposal works; valves for steam, gas and oil; check valves, foot valves, plug valves, shear gates, indicator posts, etc. EDDY valves are made in three classes; Iron Body Bronze Mounted, All Bronze, and All Iron Valves.

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For calking pipe joints under the most difficult conditions; for overhead joints or in wet places where the use of molten lead is not only impracticable but dangerous — LEAD WOOL may be used to advantage.

It makes an absolutely tight joint which will withstand the highest pressure, yet be sufficiently elastic to allow considerable sagging or settling of the pipe, without danger of leaks.

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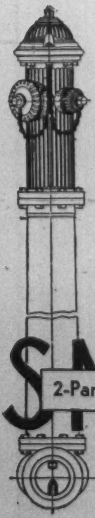


Minimum Trouble and Expense When Breaks Come

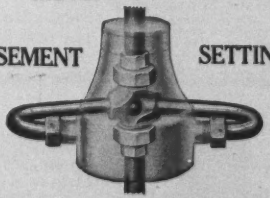
THE Smith Two-Part Standpipe Hydrant was designed to make the expense as small as possible when there is a break as the result, for instance, of careless auto truck driving.

The upper section will always break first. It can easily be renewed. And of course there can be no leakage of water because the main valve is of the compression type.

SMITH
2-Part Standpipe Hydrant

THE A. P. SMITH MFG. COMPANY
EAST ORANGE, N. J.

The
COPPERHORN
METER COUPLING
for BASEMENT SETTINGS



- 1 Meter set horizontally at desired height in vertical pipe without ells, nipples or couplings.
- 2 All copper water way. No rusting or corrosion. Freezing will not burst it.
- 3 Smooth oversize tubing and sweeping bends, maximum flow.
- 4 Meter changes do not disturb piping whether the meter in or out.
- 5 On new services it serves as a spacer to connect in the piping.
- 6 Provides a permanent electrical ground connection.

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This type of joint was designed to meet the specific requirements of certain Water Departments and is available directly on all styles of Hays Copper Service fittings.

HAYS DOUBLE SEAL JOINT

This joint features a 2-faced pipe flare (45° + 90°) and a 2-faced machined seal (45° + 90°) which is by test the strongest flanged connection available. Available by Adapter on any Corporation Stop and directly on more than 400 styles and sizes of Hays Service and Plumbing fittings.

HAYS begins at the MAIN

Since 1869 Hays has built to the exacting requirements of the Water Works Industry. Tap the Main with a Hays Tapping Machine and follow through with dependable Hays Service Fittings for iron pipe, lead or copper. Hays Corporation Stops and Curb Stops are made in all styles and sizes. Write for Catalog.

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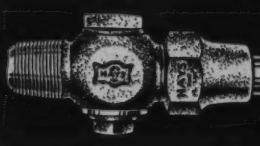

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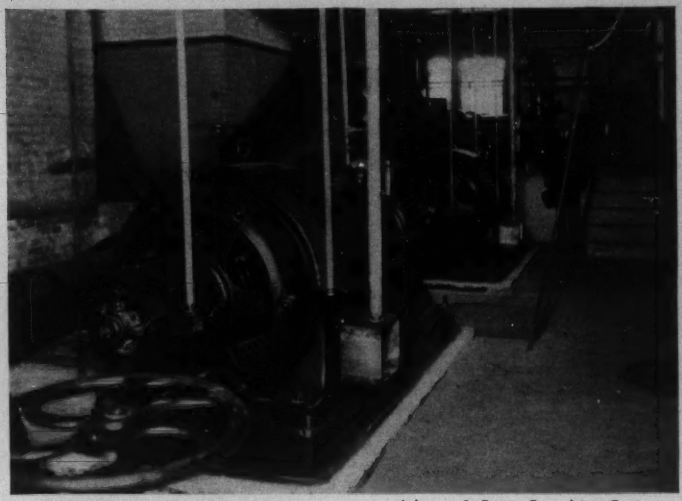

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Lawrence, Mass., investigated—made a thorough analysis of pump construction—and "5810" won! Emphasis was placed on efficiency, undivided responsibility covering the equipment, and modern engineering design of both pumps and motors.

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Water Filtration Plant.—F. O. Stevens, Consulting Engineer.

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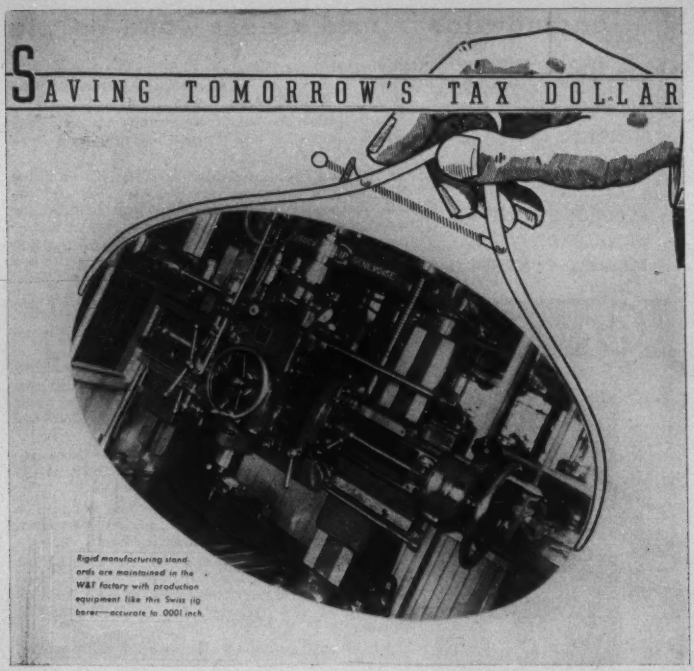

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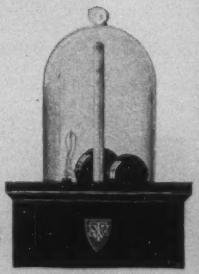

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Tomorrow's taxpayers will be uniform in praising today's selection of W&T Visible Vacuum Chlorinators.

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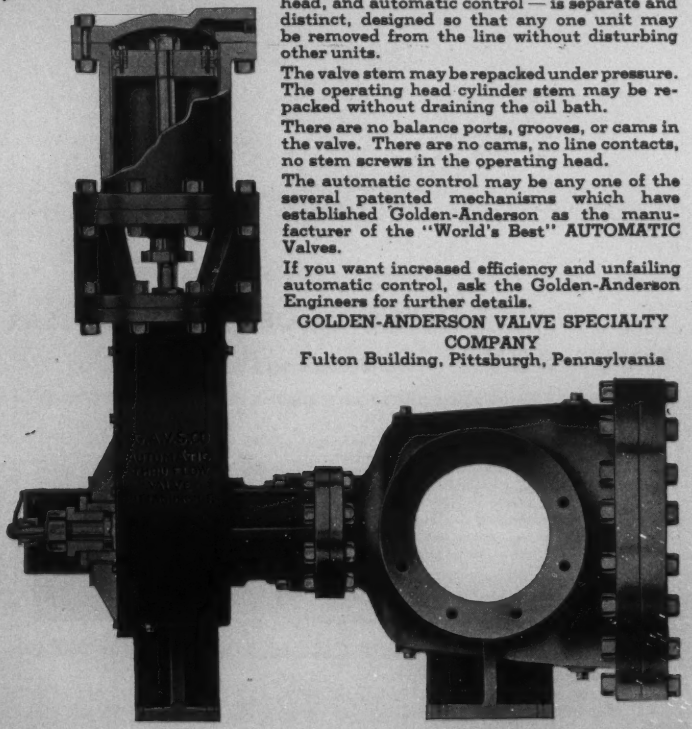

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In the new Golden-Anderson Thru-Flow Valve the plug is unseated axially, rotated, and reseated axially, all in one free and frictionless operating movement and drop tight in either open or closed position; this is accomplished by means of a simple and sturdy patented toggle type rotor mechanism which is encased in a bath of oil in the operating head.

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BITUMASTIC SPUN LINING is assigned a higher value of the coefficient *C* than any other lining. This insures the highest initial flow. More important —this high flow will be maintained for many years.

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Only 13 turns to completely open or completely close, but full flow with only 4 turns.

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New England Water Works Association

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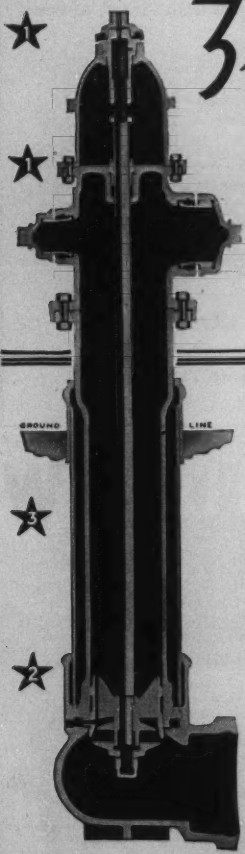
means Strictly First Class

Handsomely symmetrical—ready for action all the time—built for years and years of service — every point of Ludlow Hydrants is strictly first-class.

Compare: Full force—no obstruction in waterway. Non-freezing—drains from the bottom. Inside design—eliminates surges and water hammer. Replaceable without digging—breaks above ground in case of accident. Maintenance — all parts easily removable.

The LUDLOW VALVE MFG. CO.
TROY, NEW YORK

3 way ICE PROTECTION in MATHEWS HYDRANTS



1 The operating threads don't freeze. They are protected from outside water by a roof-like shield-operating nut, and from inside water by a packed stuffing box. These threads won't freeze because they don't get wet.

2 The hydrant barrel won't freeze. A positive and automatic drain valve empties the stand-pipe immediately after use, even in bitter weather. No properly set Mathews ever holds standing water. It can't freeze.

3 The hydrant can't be heaved or broken loose by frost. Frost only grips a Mathews around its loose, sliding protection case, which is free to lift without damage. There are no underground flanges. Frost-expanded ground can't lift or break a Mathews from its main.

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R. D. Wood Heavy-Duty Gate Valves for Water Works

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400 CHESTNUT STREET, PHILADELPHIA

Makers of SAND-SPUN PIPE, the lighter, stronger pipe, centrifugally cast in sand molds

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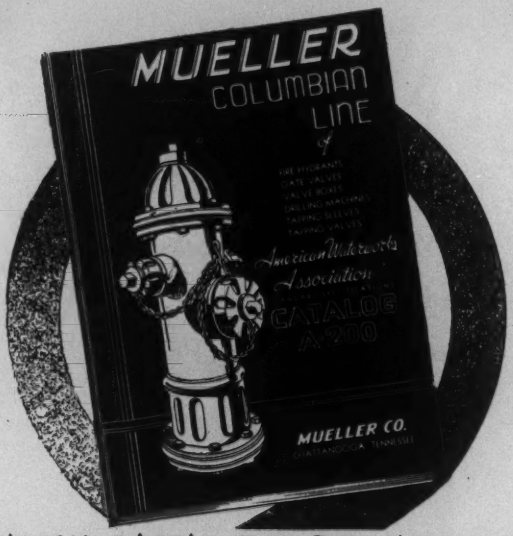

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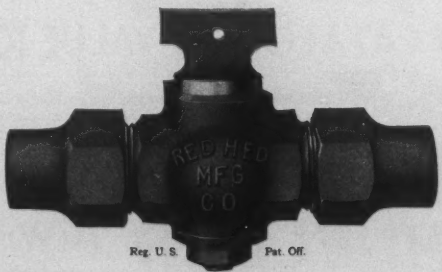

Fig. 415

RED HED MFG. CO.

Manufacturers of RED HED Brass Goods

for Water Works

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RESERVE STRENGTH

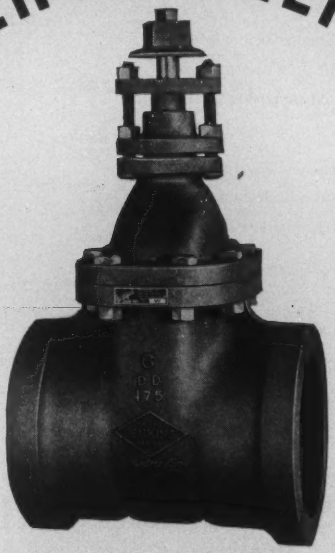

Fig. 883
Double Disc
Parallel Seat

—*makes ordinary duty easy for a Jenkins*

STRENGTH is emphasized in making Jenkins Iron Body Gate Valves for water works service. In both the Solid Wedge and the Double Disc Parallel Seat valves are many superior features that build up strength . . . that make a "Jenkins" capable of handling ordinary duty with ease. The result is longer valve life and less maintenance. This great reserve strength also enables a "Jenkins" to carry-on even if extraordinary strains are encountered.

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Jenkins Valves

BRONZE—IRON—STEEL SINCE 1864

The

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Gives a continuous record on one chart of the rate of flow from single or compound meters.

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BRAINARD & HATCH

246 Palm Street
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TO MEMBERS:

The Association is anxious to obtain back issues of the Journal. Members who have some to dispose of are kindly requested to leave them in Room 613, Statler Building.

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An Asbestos Product for economical water transportation

Ends tuberculation . . . Soil corrosion . . . Electrolysis

Costs less to install . . . Minimizes operating and maintenance costs

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Johns-Manville

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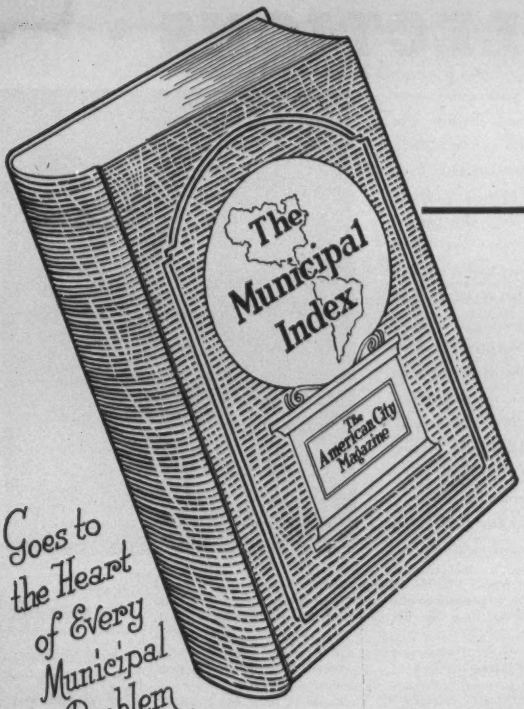


Goes to the Heart of Every Municipal Problem

THE ANNUAL PURCHASING GUIDE for MUNICIPAL and WATER WORKS OFFICIALS

Published By

THE AMERICAN CITY MAGAZINE

470 Fourth Ave., New York

REFLECTIONS . . .

MUCH water has gone over the dams and under the bridges since George Spalding read his paper before the New York Section of the A.W.W.A. May 1929 indicating the possibility of Powdered Activated Carbon furnishing a most useful tool for the removal of tastes and odors.

We reflect to the extent of looking back to see what this has meant and to date we find that since 1930 over 950 Municipal and Privately Owned Water Plants have used AQUA NUCHAR — many continuously, others only during the period of severe taste and odor epidemics.

Since that period enough AQUA NUCHAR has been used, that based on 1935 water consumption and using the average dose reported in *TASTE AND ODOR CONTROL, the following water supplies could be treated in their entirety for the period mentioned.

	Years		*Years*
Portland.....	78	Dallas.....123	
Seattle.....	384	Los Angeles...	11.8
Providence....	79	San Francisco..	42
Indianapolis...	83	Buffalo.....	18.88
Baltimore.....	19.97	Philadelphia...	7.26
Cincinnati....	39.7	Boston.....	25
Minneapolis...	43.6	Milwaukee....	26
New Orleans..	61.9	Chicago.....	2.23
St. Paul.....101		New York City	2.32

If the average dose as reported by the pioneer user of Powdered Activated Carbon were utilized, this amount of AQUA NUCHAR would treat the entire supplies for a period of three years:

Seattle	San Francisco
Dallas	Cincinnati
St. Paul	Milwaukee
Indianapolis	Boston
Providence	Baltimore
Portland	Buffalo
New Orleans	Los Angeles
Minneapolis	Philadelphia

In addition to this there has been sufficient Activated Carbon sold by competition during the same period to treat in excess of three hundred billion gallons of water using an average dose based on survey in *Taste and Odor Control.

*May 1936 Vol. 2 No. 9.

The purpose of the above figures is to show the wide acceptance of Activated Carbon for Taste and Odor Removal and to assure those large municipalities who will be considering in the near future, the application of this product as a means of controlling tastes and odors, that a sufficient amount of Activated Carbon in the form of AQUA NUCHAR is available from three of our plants, and in addition there is additional capacity in this Country to satisfy the requirements of the largest municipalities.

INDUSTRIAL CHEMICAL SALES CO.

230 Park Avenue NEW YORK CITY | 418 Schofield Building CLEVELAND, OHIO | 205 W. Wacker Drive CHICAGO, ILL.

REFLECTIONS IN RETROSPECT

IT seems but a very short while ago since George R. Spalding demonstrated at Hackensack, New Jersey, the effectiveness of powdered activated carbon in the treatment of water for taste and odor removal. Previously, attempts had been made to introduce the product in granular form but indications of high equipment cost and uncertainty of results had made water operators somewhat skeptical of this new medium as a dependable and economical purification tool.

Literally, much water has gone over many dams since that time — six or seven years ago, and the doubts and fears then felt have been entirely dissipated. So great has been the progress in the adoption and use of powdered activated carbon as a positive means to control tastes and odors in drinking water, that in the neighborhood of 1,000 plants — municipally and privately owned — in this Country alone have proven its benefits in this respect and its use is fast spreading throughout the world; a testimonial to the initiative and enterprise of those responsible for the operating of American water plants.

Today, there is such faith and confidence in activated carbon as a means of eliminating tastes and ordors, that its use can be safely looked upon as a standard purification practice and no other method of water purification has achieved such a position in so short a time; surely concrete evidence of the merit of the product for such purpose.

In retrospect, one can go back to the questions of doubt that were raised; such as, powdered carbon would not be removed in the sand filters; it might decrease the filter runs, also accelerating mud ball formation. It was further questioned whether powdered carbon would remove tastes and odors of a serious nature, or, if it did, the treatment would be too costly. Wide experience in operating hundreds of water plants had proven to the contrary, and it has been demonstrated conclusively that there is no taste and odor condition which cannot be corrected when an adequate quantity of Aqua Nuchar is used.

Trouble with the control of taste and odor is one of the biggest worries of the water plant officials because such a condition reaches and registers in every home in the community. Naturally, the cost of furnishing a uniformly palatable water at all times must be considered. In the case of unusual taste and odor epidemics, quantities up to 300 lbs. of Aqua Nuchar per million gallons have been used but such conditions rarely occur, and during a period of twelve months the cost per million gallons is negligible. Taking the average case, an official study of over one hundred water plants shows the average quantity reported was approximately 16 lbs. per million gallons; and even if this average was doubled, obviously it would be a very small amount to pay for water that satisfies.

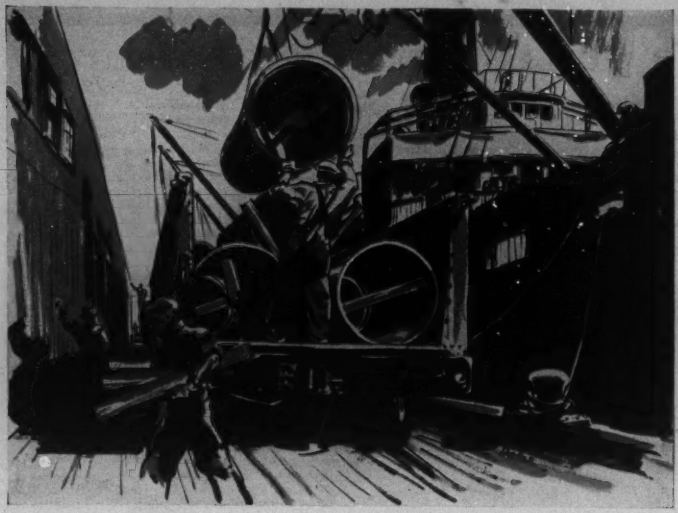
As the use of powdered activated carbon became wider, some further benefits from the treatment developed. For example, the application of the carbon along with the alum in the mixing chamber has resulted in a better floc formation and, in some cases, to such an extent that the amount of coagulant has been reduced. Further, it has been convincingly proven that the sludge in the sedimentation basin is stabilized by inhibiting decomposition, preventing gas formation and the incidental scum. In certain plants where the supply of raw water is badly contaminated, necessitating super-chlorination, it has enabled the operators to get rid of the objectionable chlorine taste by reason of the carbon acting as a dechlorinator, so that these operators can not only supply an absolutely safe water but also a palatable one, thus getting ride of a lot of complaints.

Today, activated carbon is the cheapest form of insurance that a water plant can take out to protect the palatability of its supply under all and any conditions. Necessarily, such conditions vary considerably throughout the Country and where epidemics occur — as they sometimes do — the cost of the carbon may seem high during this temporary situation. It is calculated on the basis of 20 lbs. of carbon per million gallons of water used each day in the year based on a per capita consumption of 100 gallons daily, it would make the cost to each individual within the community only slightly over 3 cents per year. To those plants who are subject at certain seasons to severe epidemic conditions, we recommend the use of a small quantity of Aqua Nuchar every day, depending upon individual circumstances, as being more economical because when the carbon is well distributed throughout the plant as the severe tastes and ordors arise, the condition will not reach a point where excessive dosages are needed. Such a procedure will provide maximum insurance of palatable water without increasing the total premium paid.

J. Grant

Sales Manager.

Following the trend of the times towards the merging of all subsidiaries under parent management; about December 1st, we will cease to be a separate corporate entity and will function as the Chemical Sales Division of the West Virginia Pulp and Paper Company.



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U.S.
cast iron
PIPE

SUPER-DE LAVAUD CENTRIFUGAL CAST IRON PIPE

U. S. Pit Cast Pipe
U. S. Mechanical Joint Pipe
U. S. Flexible Joint Pipe
U. S. Threaded Cast Iron Pipe
U. S. Ni-Resist Cast Iron Pipe
U. S. Cast Iron Culverts
U. S. Cast Iron Roof Plates
Alloy and Gray Iron Castings

The Journal of the New England Water Works Association

is a quarterly publication, containing the papers read at the meetings, together with reports of the discussions. Many of the contributions are from writers of the highest standing in their profession. It affords a convenient medium for the interchange of information and experience between the members, who are so widely separated as to find frequent meetings an impossibility. Its success has more than met the expectation of its projectors; there is a large and increasing demand for its issues, and every addition to its subscription list is a material aid in extending its field of usefulness.

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LEADITE helps to complete the job in "quicker time,"—and actually "saves" money from every angle of pipe laying.

Most anyone can make a LEADITE JOINT,—because LEADITE is very easy to handle,—just yarn the joint,—pour it full of molten LEADITE and the joint is finished.

LEADITE resists electrolysis, and does not corrode or rust.

Further,—LEADITE has been successfully tested and used under various conditions,—for more than 35 years. In fact—*thousands of miles of water mains throughout the country are jointed with LEADITE.*

Water Works Men most everywhere are specifying and using LEADITE on large and small installations.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 35 years.
Saves at least 75%

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